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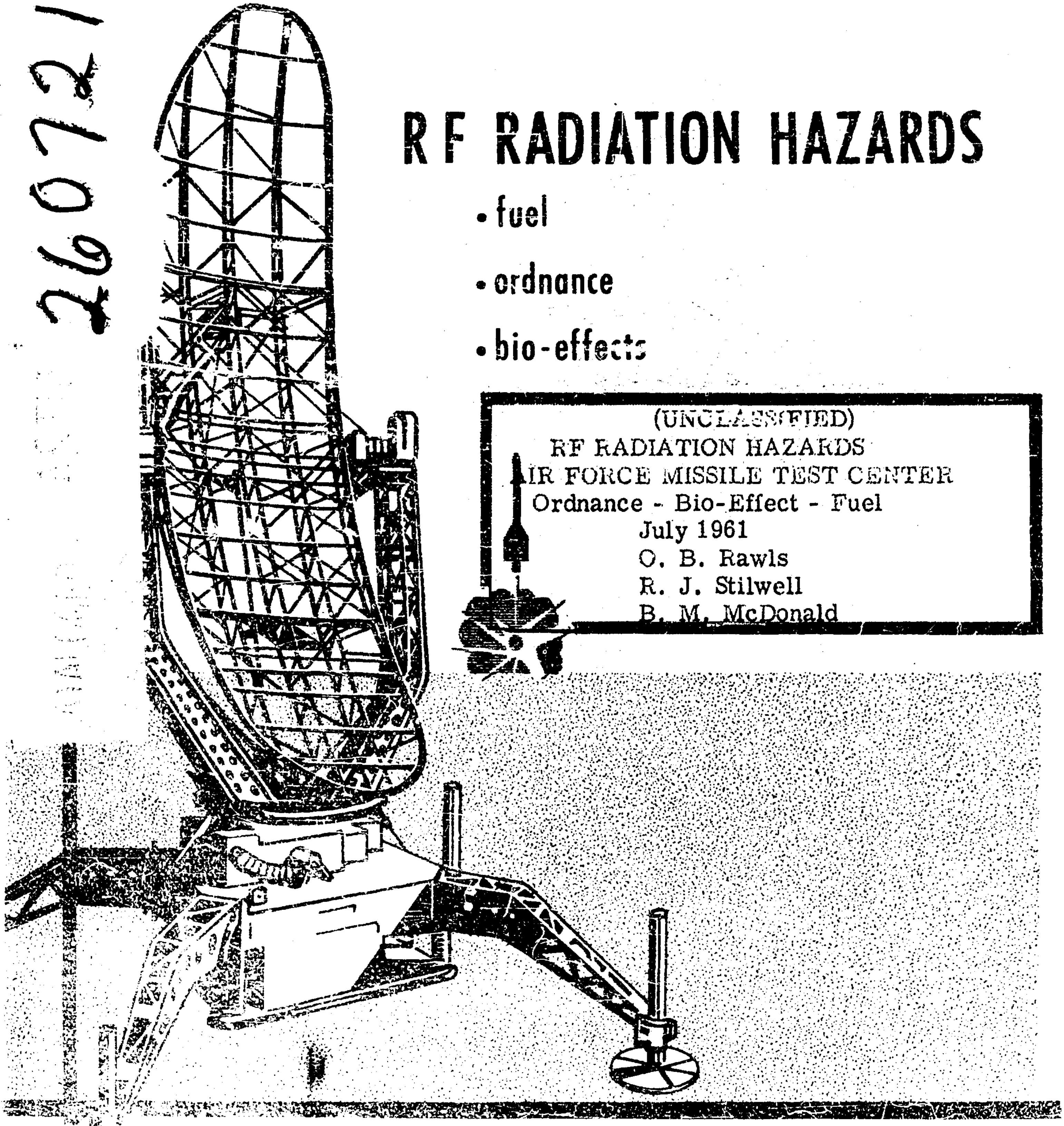
RF RADIATION HAZARDS

- fuel
- ordnance
- bio-effects



(UNCLASSIFIED)
RF RADIATION HAZARDS
AIR FORCE MISSILE TEST CENTER
Ordnance - Bio-Effect - Fuel
July 1961

O. B. Rawls
R. J. Stilwell
B. M. McDonald

[illegible] Control and Analysis - - - RANGE OPERATIONS RCA AFMTC

UNCLASSIFIED

AFMTC-TR-61-14
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RF RADIATION HAZARDS

AIR FORCE MISSILE TEST CENTER

ORDNANCE - BIO-EFFECTS - FUEL

O. B. Rawls
R. J. Stilwell
B. M. McDonald

Frequency Control and Analysis
Range Operations

RCA W. O. 047832

July 1961

RCA SERVICE COMPANY
MISSILE TEST PROJECT
Patrick Air Force Base
Florida

Prepared by the RCA Service Company
Missile Test Project, under Sub-Contract
to Pan American World Airways, Inc.

This technical report replaces report AFMTC- TN-59-4 dated July 1959, which should be disposed of according to proper Security Regulations.

FOREWORD

It is the purpose of this report to provide instructions and guide lines to Air Force and Range Contractor personnel on radiation hazards related to ordnance devices, bio-effects and fuel. It should also prove beneficial to Missile Contractors by providing their ordnance design engineers with information on the external radiation environment in which their ordnance devices will be operating or subjected during installation.

Information on radiation sources not operated by the Range Contractor was obtained from appropriate supervisory personnel by visitation to the field sites. Information on radiation sources operated by the Range Contractor was obtained from technical files on the instrumentation systems. Every effort has been made to eliminate errors in the tabulated parameters and characteristics of the instrumentation systems involved.

A bibliography of the reference material used in the preparation of this report is included at the end of each part. Throughout the report reference to previous work is indicated by the author's name followed by numerical reference to the applicable bibliography.

Current Tri-Service research on radiation hazards in the three problem areas and future changes in A.F.M.T.C. instrumentation may make portions of this report obsolete. Changes in the status of radiation levels will not be disseminated in the future by publication of additional reports but will be covered by publishing revisions to this initial document. This will insure an up-to-date document for field personnel and other interested parties. A plastic aid and instructions for adding or replacing pages has been included in the rear of the report.

From time to time information on radiation levels may be required which are not covered in this report. Range Contractor personnel who require radiation measurements may obtain this service by telephone, confirmed later in writing, to:

Operations Planning (FCA)
Building 989-2, Room 2-101
Mail Unit 943
Patrick Air Force Base, Florida
Telephone, PAFB UL7-4162 or UL7-6349

Missile Contractors and/or Air Force Military Units should request radiation measurements service through:

Commander
Air Force Missile Test Center
Patrick Air Force Base, Florida
Attention: MTRCF
Telephone: PAFB UL7-4208

Although great care has been exercised in the preparation of the report, some errors may have been overlooked because of the large number of tabulations involved. Please forward any detected errors to either of the above addresses.

This report supersedes AFMTC - TN - 59 - 4 which should be destroyed in accordance with applicable security regulations. Distribution is through ASTIA and in accordance with regulations governing this organization.

Special acknowledgement is made to the RCA Systems Analysis Unit for their review and comments on the entire report; and to Colonel George M. Knauf, Director of Occupational Health Laboratory, P.A.F.B. for his review and comments on Parts II and III.

O. B. Rawls
Leader
Frequency Control & Analysis

ABSTRACT

An analysis of Air Force Missile Test Center radiation sources, which constitute potential radiation hazards, is discussed. The analysis is in three parts; Parts I, II and III deal with ordnance, bio-effects and fuel, respectively.

Within Parts I, II and III, tabulations have been included which show the extent of hazardous radiation to ordnance for each missile complex, the areas dangerous to personnel; and the areas surrounding the individual instrumentation systems within which fueling operations may be dangerous when irradiated.

A map of Cape Canaveral showing instrumentation site locations and average effective radiated powers is included as an appendix.

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PART I

ORDNANCE

RF RADIATION HAZARDS

July 1961

INTRODUCTION

The requirement to communicate reliably and to detect and track small objects at large distances has resulted in the recent development of high gain antennas and transmitters capable of producing radio frequency field intensities here-to-fore not encountered.

Accompanying this trend of increasing field intensities has been a growing concern about radiation hazards. It is now generally recognized that R-F radiation, under certain conditions, is a hazard to ordnance devices. At the Air Force Missile Test Center the problem is aggravated because many ordnance items are designed to perform their intended function without regard to the electromagnetic field intensities prevalent from radiation sources located external to the test vehicle

Not all pyrotechnic devices are susceptible to premature ignition by electromagnetic radiation. The devices of prime interest are the electrically activated types; these are generally referred to as electric squibs or squib-initiators. Electric squibs usually contain two wire leads, a bridgewire, an ignition charge, a primer and/or a detonator charge. Support posts for the bridgewire, formed from the ends of the wire leads, the bridgewire and charges are encapsulated in a small metallic container. Electric power is supplied through the external wire leads. In some

applications electric squibs are of the plug-in-type; the plug pins form the major portion of the exposed wiring thus increasing the safety factor at longer wavelengths.

A special arc type electric squib is sometimes used for high speed operations in which no bridgewire is used. The firing potential required to establish the electrical arc between two closely spaced electrodes is in the order of thousands of volts. This type will not be considered because of the high firing potentials required, the separation distance between radiation source and the squib involved and the fact that none are known to be in use at the Missile Test Center.

From data gathered on electric squibs it is apparent that very little is known of their R-F characteristics. Many agencies are conducting studies to determine these R-F characteristics but until explicit information is made available D-C characteristics must be utilized with theoretical considerations to determine which radiating systems are hazardous and must be silenced while susceptible ordnance devices are handled.

In the following sections an analysis of the various radiation sources in use at the Air Force Missile Test Center is discussed. The theoretical power contributed by radiating systems which operate above 30 megacycles

to a hypothetical squib with overall lead length of one meter is calculated and tabulated for each launch complex. Radiation sources located within each missile have not been considered. Range Radiation sources operating below 30 megacycles have been considered in the Squib Power Absorption Characteristics Section on Page 9. The total power contributed by all external radiation sources, collectively, has also been tabulated.

DISCUSSION

The Ordnance Hazard

A hazardous condition exists when any source of electrical energy is present, active and capable of producing in the squib bridgewire circuit the minimum required firing power or more. This energy may be provided through related hard wire circuitry as from a battery, generator or capacitor; through inductive or capactive coupling to unrelated wiring; by the static discharge, and through pickup of radiated electromagnetic energy. In addition to the "in situ" hazard, a hazard may exist while transporting and handling such devices. The degree of hazard to personnel is dependent in some cases on whether the usual associated high explosive charge is connected to the initiator at time of activation.

Unfortunately, the maximum no-fire energy of a particular squib is not a discrete and fixed characteristic. It must be determined indirectly by familiar statistical methods resulting in the specifying of a maximum no-fire current for a certain ignition probability, frequently 0.1%. Quality Control methods are in use which result in the rejection of entire lots when any item of a sample group, taken from the lot, activates on specified no-fire current values.

Quality Control is believed to be thorough enough to safely permit use of

specified no-fire current values in the determination of maximum no-fire power.

Accurate information about the maximum no-fire for all squibs of a particular type is useful since this power should be independent of frequency and therefore can be used in calculations at radio frequencies.

Normal Safety Practices During Handling of Squibs

It is commonplace to parallel a very low resistance shunt across the firing leads of sensitive electric squibs; it should be observed, however, that this can only be effective when dealing with an energy source having a high impedance compared to the resistance of the shunt and squib in parallel, since, for low impedance sources the voltage across the squib bridgewire is virtually the same with or without the shunt. The shunt does provide an extra bleeding path for rapidly discharging static charges and, in effect, lowers the load impedance.

Twisting the wire leads of firing circuits may result in as much as 20 db of attenuation. Twisted leads are standard on Dupont ordnance devices. Shielded leads are preferable and used in some installations such as the Thor, Mace, Matador, Titan and Atlas. With shielded leads the R-F attenuations is considerably larger than with twisted leads alone.

Calculations indicate that ordinary shielded wire should provide about 40 db absorption of impinging radio waves. For safety reasons only 20 db attenuation should be used in calculations to compensate for shielded leads.

The elimination of exposed wire leads by the use of plug-in squibs in metal cases should eliminate the hazard from external radiation sources. While transporting or transferring squibs, at wave lengths five times the plug pin length or longer. Many plug-in squibs are in use on the Thor, Titan, and Atlas missiles, however, not all squibs in use have been converted to plug-in types.

R-F filters have been inserted in series with some of the shielded firing circuit leads in the Thor missile to further reduce the hazard to sensitive ordnance devices.

Weinbaum (5) has calculated the shielding efficiency of an aluminum enclosure on the Atlas destructor package. According to his calculations approximately 165 db of attenuation occurs plus another 106 db for reflection loss making a total shielding efficiency at 1 megacycle of 271 db. As the frequency increases, the shielding efficiency tends to increase.

Under development are squibs using special R-F attenuating materials around lead wires forming a high-loss R-F transmission line. These have proven

very effective at microwave frequencies and to a smaller degree down to about 50 to 100 megacycles. Future use of this type of squib, when it becomes available, will further reduce the hazard.

Finally, the practice of turning off radiation sources during critical periods has been used. It is the most effective procedure, obviously, but in general the least desirable since it reduces the simultaneous-operations capability of the range.

Radiation Sources

Present Cape Canaveral and Patrick AFB sources of RF energy which are considered possible hazards are shown in Table V of this report with the exception of HF transmitters. There are 21 high frequency communication transmitters with an output capability of 27 channels simultaneously at power outputs ranging from 250 to 3000 watts average and up to 45,000 watts peak envelope power. The power output of VHF and UHF communication transmitters are insignificant relative to other radiation sources and are not considered hazardous. The locations and average effective radiated powers of Cape Canaveral radiation sources are shown on Drawing B-97411 in the Appendix.

Five high power radiation sources are located at Patrick Air Force Base. These include the AN/FPS-6, AN/FPS-20, AN/CPS-9, AN/FPS-16 (XN-1)

and MPM-11C radars. Patrick Air Force Base is about 13.7 nautical miles from the nearest launch pad at Cape Canaveral.

The nearest downrange station to the missile staging and launching area at Cape Canaveral is Grand Bahama Island at a distance of about 165 nautical miles. High power radiation sources at downrange stations are not hazardous to ordnance items at Cape Canaveral by virtue of their separation.

Tables I and II are tabulations of the high-frequency transmitters and transmitting antennas used for radio communications. Of primary concern are the high-power transmitters operating with high-gain antennas in the proximity of missile launch pads and assembly areas such as Polaris and Pershing. To date, the frequencies of operation have been confined below an upper frequency limit of 30 megacycles. The electrical characteristics of squibs and their behavior at frequencies below 30 megacycles is therefore of considerable concern.

Table IV is an inventory of the command-destruct antennas and transmitters at Cape Canaveral including a tabulation of simultaneous radiation capabilities. Current test requirements limit adjustable antenna elevations to vertical angles between 20 and 50 degrees and antenna azimuth setting requirements are contained within a clockwise sector extending from 45 to 130 degrees true.

Squib Power Absorption Characteristics

Although data on squib R-F Characteristics in general are not available one missile contractor supplied R-F impedance information on four types of squibs installed in its test vehicle.

From the data presented it appears the resistance is a significant part of the squib impedance up to about 600 kilocycles, above which, the squib impedance is determined almost entirely by the reactive component. The R-F resistance at 200 megacycles increased by an average factor of about 30 over the D-C resistance value. D-C resistance ranged from 0.145 to 1.5 ohms for the four types. Between 0.6 and 200 megacycles the induced voltage required for a given squib bridgewire current is therefore proportional to the squib reactance assuming bridgewire resonance does not occur. This neglects the source impedance of the induced voltage which if significant would further decrease the current flow and increase the required induced voltage for a given squib current.

Weinbaum (5) has measured the input impedance of an Atlas separation cartridge (PN 7-04285-D). The specified D-C resistance of the cartridge is 0.7 to 1.3 ohms. The cartridge displayed a cyclic variation in input impedance becoming purely resistive at about 500, 1200, 2400, 3500, 5800 and 8500 megacycles.

Assuming his slotted line was a 50 ohm type the resistance and reactive components at 160 mc compare favorably with the impedance obtained at 200 mc for two of the four squibs mentioned previously. The measured values are tabulated below:

D-C Resistance	Frequency	Impedance
0.7 to 1.3	160 mc	5 + j46
0.62	200 mc	7.5 + j53.5
0.42	200 mc	3.1 + j44

These characteristics have been tabulated to show the divergence of impedance values for three squibs with similar D-C resistance characterisitcs. There was even greater divergence of R-F impedance between the other two squibs and those tabulated above.

Three different measuring methods have been used at AFMTC to evaluate the R-F impedance characteristics of two types of squibs. These included the impedance bridge, the slotted line and the wire substitution method. Some divergence of measured values occured between different measuring methods as well as between individual squibs.

This variation of impedance with frequency, squib type and, probably, the measuring method indicates the complexity of the problem and time required to evaluate each type individually. Wing Com. R. I. Gray of the R.A.F. (Reference 9) points out the futility of impedance measurements because of expected impedance variations with line length and configuration.

The time limitation necessitates that an alternate approach be used. The approach must insure a safe condition. Certain assumptions, therefore, must be made regarding the radio frequency characterisitcs of squibs.

These assumptions must lead to results which insure the safe conditions mentioned above and are not unreasonable or unrealistic to the point of curtailing operations unnecessarily.

The safest assumption, regarding impedance, is that the squib presents a conjugate impedance match, independent of frequency, for any squib wirelead configuration as an antenna. This assumption results in the transfer of maximum power to the squib and represents the most hazardous condition. The assumption is reasonable except at frequencies below 30 MC where squib lead lengths are small relative to a wavelengthand the squib impedance is but a few ohms.

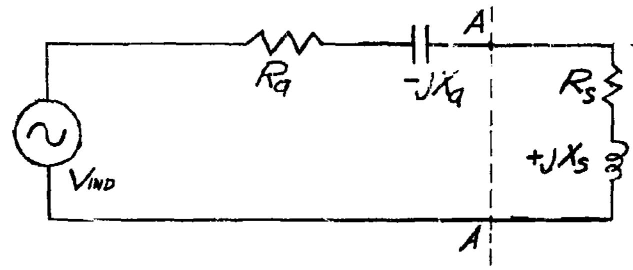
In general, the resistive component of an antenna impedance decreases and the reactive component increases rapidly as the length decreases below four tenths of a wavelength, (Kraus, Reference 1 Page 242). The magnitude of the impedance is a function of the length to radius ratio and increases rapidly as the frequency is lowered being determined primarily by the reactive component.

Thevenin's theorem can be used to obtain an equivalent generator for the

short antenna. The effective length is approximately equal to its physical length, and the voltage induced is equal to the electric field strength times the effective length. The internal impedance of the equivalent generator is a resistance in series with a capacitance as shown to the left of A-A

in Figure "A"

Short Dipole
Equivalent
Generator



Squib

The short antenna consists of the squib wire leads, and the squib comprises the load connected to the equivalent generator terminals.

It should be noted in Figure A, that maximum current would flow in the external circuit when the load impedance is short circuited. Since the squib impedance is small, the magnitude of the maximum squib current is determined primarily by the short antenna impedance at each frequency.

For frequencies below 30 megacycles maximum squib current is of interest since an impedance match between squib impedance and short antenna impedance is very unlikely.

To solve for total squib current let

$$P_i = I_i^2 \; R_s$$

and

$$I_i = \frac{V_i}{Z_i} = \frac{E_i \; h_i}{Z_i} \qquad (Z_i \gg R_s)$$

where

P_i = the squib power at any frequency f_i

I_i = the R.M.S. squib current

R_s = the squib R-F resistance assumed constant

V_i = the squib dipole induced voltage

Z_i = the squib dipole impedance $R_i - jX_{ci}$

E_i = the electric field strength

h_i = the squib dipole effective length

The squib total power becomes

$$P_t = P_1 + P_2 + \dots\dots\dots\dots P_i$$

$$= \frac{(E_1 h_1)^2 R_s}{Z_1^2} + \frac{(E_2 h_2)^2 R_s}{Z_2^2} + \dots\dots\dots \frac{(E_i h_i)^2 R_s}{Z_i^2} \quad (1)$$

Multiplying and dividing by $R_o{}^2 h_o{}^2$ and rearranging terms, where R_o is the resistance of a center fed $\frac{\lambda}{2}$ resonant dipole and h_o is its effective height we have

$$P = R_s \left[\left(\frac{R_o h_i}{Z_i h_o}\right)^2 \left(\frac{E_i h_o}{R_o}\right)^2 + \left(\frac{R_o h_2}{Z_2 h_o}\right)^2 \left(\frac{E_2 h_o}{R_o}\right)^2 + \dots \left(\frac{R_o h_i}{Z_i h_o}\right)^2 \left(\frac{E_i h_o}{R_o}\right)^2 \right] \quad (2)$$

The expression within the brackets is equivalent to a total I_{rms} squared value of current and the total power is

$$P_t = R_s I^2_{rms}$$

Each term within the brackets of Eq. (2) contains two factors. The factor $\frac{(E_i h_o)^2}{R_o^2}$ is the RMS squared value of current that would flow in the load of a short circuited $\frac{\lambda}{2}$ resonant dipole at any frequency f_i. The ratio

$\frac{R_o^2 h_i^2}{Z_i^2 h_o^2}$ can be considered a compensating factor which compensates for the fact the actual dipole is not a $\frac{\lambda}{2}$ in length.

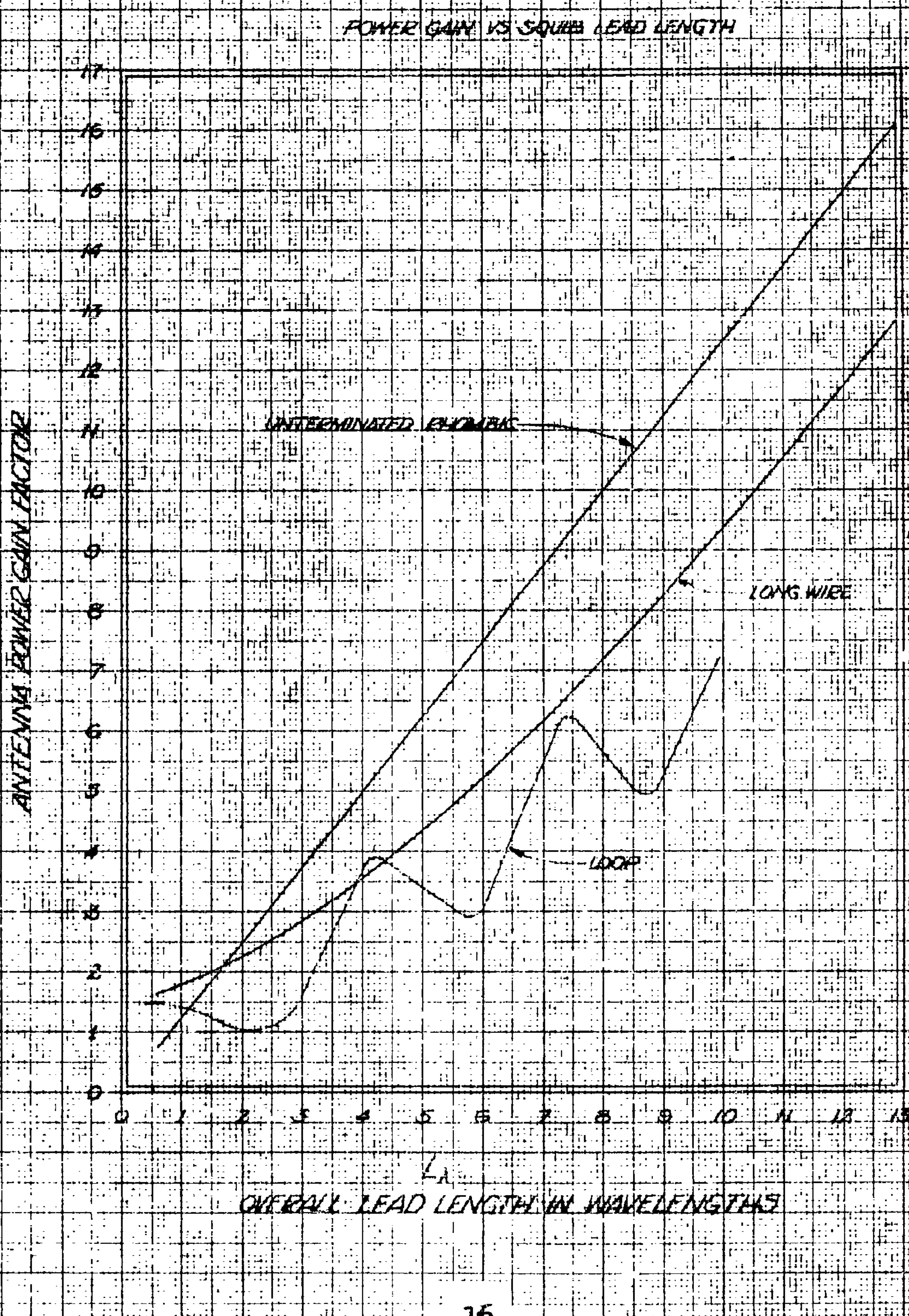
In Eq. (2) $Z_i > R_o$ and $h_o > h_i$; consequently $\frac{R_o}{Z_i} < 1$ and $\frac{h_i}{h_o} < 1$ for dipole lengths shorter than about 0.45 λ . The sum of the terms within the bracket of Eq. (2) will be a maximum when Z_i equals R_o and $h_i = h_o$.

The total power under this condition becomes

$$P_t = R_s \left[\frac{(E_1 h_o)^2}{R_o^2} + \frac{(E_2 h_o)^2}{R_o^2} + \cdots\cdots\cdots \frac{(E_i h_o)^2}{R_o^2} \right] \qquad (3)$$

Eq (3) represents the power delivered to a squib with leads $\frac{\lambda}{2}$ long at all frequencies which of course is not physically possible. It does however provide a basis for evaluation of the hazard since the expression within the brackets can be numerically evaluated and if below the no-fire current of the most sensitive squib a safe condition can be assumed to exist. The assumption is valid because of the factor $\frac{R_o^2 h_i^2}{Z_i^2 h_o^2}$ in Eq. (2) which becomes very small as the frequency decreases.

FIG. I


POWER GAIN VS SQUIB LEAD LENGTH
ANTENNA POWER GAIN FACTOR
UNTERMINATED RHOMBIC
LONG WIRE
LOOP
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
L_λ
OVERALL LEAD LENGTH IN WAVELENGTHS

To evaluate Eq. (3) field strength measurements were made in those launch pad areas considered hazardous because of thier proximity to the communications antenna field. These hazardous areas consisted primarily of launch pads 25A, 25B, 29, 30 and 30A and missile assembly areas in Hangar Y.

In addition to field strength measurements, the areas were explored with a resonant and non-resonant antenna with 0-100 RF milliampere meter installed at its center.

The results of the Hangar Y field intensity measurements are tabulated below followed by an evaluation of Eq. (3).

Ant Type	Wave Length	Dipole Lengths	Dipole Effective Length	Electric Field V/M	Dipole Induced Voltage	$I = \frac{V_1}{R_0}$ ind MA.
Discone	110	.32 λ	35.2 M	0.18	6.34	86.9
Discone	51.5	.32 λ	16.5 M	0.04	0.66	9.1
Rhombic AA	14.9	.32 λ	4.8 M	0.03	0.14	2.0
Rhombic AA	11.3	.32 λ	3.6 M	0.05	0.18	2.5

From Eq. (3)

$$I^2_{rms} = (86.9)^2 + (9.1)^2 + (2)^2 + (2.5)^2$$

$$= 7520 + 83 + 4 + 6.2$$

$$= 7613.2$$

$$I_{rms} = \sqrt{7613} = 87.5 \text{ Ma.}$$

Field Intensity measurements at launch pads 25A, 25B and 29 let to similar results. The most sensitive squib used in the areas adjacent to the

the communications antenna field has a maximum no-fire current of 100 milliamperes DC. It is concluded that for the systems itemized in Table II no hazards exist to ordnance items with leads less than fifteen feet long overall or seven and one-half feet from squib to either end.

No indication of R-F current could be obtained in any of the areas with dipole and R-F milliampere meter.

Above 30 MC the effective electrical aperture or area of the squib in absorbing power from impinging radio waves is the most difficult characteristic to evaluate. It would be desirable to consider a receiving system whose directional gain properties increase with frequency. This more closely approaches the actual case since the gain of a squib with fixed length leads would, in general, increase with frequency. Since it has been assumed that the squib impedance properly matches the impedance of any antenna configuration, the receiving system can be considered on the basis of gain only.

The gains of the long wire, loop and unterminated rhombic antenna configurations have been determined and plotted in Figure 1, Page 16, as a function of overall lead-length in wavelenghts. From the graphs it can be seen the unterminated rhombic configuration has the largest gain down to 2 λ below which the long wire configuration becomes the largest.

All three wire lead configurations are possible. The safety practice of using a shunt across the squib would make the loop and rhombic configurations most likely.

Harper (3) has plotted the theoretical directivity of a maximum design, terminated, rhombic antenna in free space as a function of wavelengths per side. Within about 1/2 db, the directivity is a linear function and equal to 10N where N is the number of wavelengths in each leg or side. For the terminated case the signal gain would be one-half the directive gain because of the power lost in the terminating resistance. Other losses, such as ground loss, have been neglected and the terminated signal gain has been taken as $\frac{10N}{2}$. For the unterminated case the directive gain would be one-half that of the terminated case since back lobes would exist. The signal gain would remain the same because no power is lost in a terminating resistor. The squib signal gain, therefore, is considered to be $\frac{10N}{2}$ down to an overall lead-length of 2λ, where

$$N = \frac{L}{4\lambda} \tag{4}$$

L = Overall length of squib leads in meters

λ = Wavelength under consideration expressed in meters.

Squib signal gain in terms of wavelength and lead-length then becomes

$$G = \frac{5L}{4\lambda} \tag{5}$$

From Eq. (2) and the relation

$$A_e = \frac{G\lambda^2}{4\pi} \qquad (6)$$

the squib effective aperature for a lead-length of 2 λ or more becomes

$$A_e = \frac{5L}{16\pi} \qquad (7)$$

Kraus (1) gives the gain of the $\frac{\lambda}{2}$ resonant dipole as 1.64 and that of a short dipole as 1.5. The difference in gain is 0.38 db. The short dipole configuration is not considered because of the small difference in gain. For squib lead-lengths between $\frac{\lambda}{2}$ and 2λ the signal gain can be obtained from the "long wire" graph in Figure 1 and for lead-lengths less than $\frac{\lambda}{2}$ the gain can be considered constant at 1.64.

The squib effective aperture for lead-lengths of $\frac{\lambda}{2}$ to 2λ can be obtained from Eq. (6), and gain obtained from Figure 1. For lead-lengths below $\frac{\lambda}{2}$ the effective aperture becomes

$$A_e = \frac{1.64\lambda^2}{4\pi} \qquad (8)$$

Since squib lead-lengths are usually given in inches the following equation is useful in conjunction with Figure 1 for obtaining gain

$$L\lambda = \frac{L_{in}\, F_{mc}}{11,880} \qquad (9)$$

where

$L\lambda$ = Overall lead-length in wavelengths

L_{in} = Overall squib lead-length in inches

F_{mc} = Frequency under consideration in megacycles

It is of interest to note the frequencies at which transistion occurs from the rhombic to the long-wire antenna and from the long-wire to the $\frac{\lambda}{2}$ antenna configurations. Transition from the rhombic to long-wire occurs at a wavelength given by

$$\lambda m = \frac{L_m}{2} = \frac{L_{in}}{78.8} \qquad (10)$$

and at a frequency of

$$f_{mc} = \frac{300}{\lambda m} = \frac{23,640}{L_{in}} \qquad (11)$$

Transition from the long-wire to the $\frac{\lambda}{2}$ configuration occurs at a wavelength and frequency given by

$$\lambda m = 2L_m = \frac{L_{in}}{19.7} \qquad (12)$$

$$f_{mc} = \frac{300}{\lambda m} = \frac{5910}{L_{in}}$$

where

f_{mc} = Frequency in megacycles

λm = Wavelength in meters

L_m = Lead-length in meters

L_{in} = Lead-length in inches

For a squib with overall lead-length of 1 meter or 39.4 inches transitions would occur at 600 mc (rhombic to long-wire) and at 150 mc (long-wire to $\frac{\lambda}{2}$ dipole).

From the data tabulated in Table I it can be seen that squib unshielded leads do not exceed 1 meter. Where longer leads are indicated in Table I this includes internal wiring within the test vehicle. Internal squib firing-circuit wiring is usually shielded. In those cases where it is not, shielding is still provided by the test vehicle skin. It is unlikely over 40 inches of unshielded wire would ever be exposed to direct radiation. Lot "A" Titan test vehicles were an exception prior to the completion of the test program. The long unshielded leads in the lot "A" series have been replaced by shielded leads in the "B" series.

The absence of specific information regarding the R-F characteristics of all squibs used at A. F. M. T. C. and the divergence of the R-F impedance of the types which have been measured prohibits exact evaluation of the hazard to each type. It would be desirable therefore to have, as a reference, a hypothetical squib with electrical properties duplicating the most hazardous condition. The squib hazard relative to the "hypothetical" squib hazard may then be estimated.

The properties of our "hypothetical" squib would have the following characteristics:

1. A maximum no-fire power level equal to the product of the squib D-C resistance and the square of the maximum no-fire D-C current.

2. An overall lead-length of 1 meter shielded or unshielded in agreement with the actual squib.

3. A conjugate impedance to that of the lead wires for any configuration as an antenna and for any frequency.

4. Power gains and effective apertures in agreement with Eqs. (5), (6), (7) and (8).

Having defined the effective aperture/frequency relationship, lead-length and impedance of our "hypothetical" squib only the radiated power density from each source remains to be determined before the squib absorbed power can be calculated.

Radiated Power Densities

The free-space radiated power density from any radiation source may be calculated from the following equation:

$$P = \frac{ERP}{4\pi r^2} \tag{13}$$

where

P = Field intensity in watts per square meter

ERP = Effective radiated power in watts

r = Distance from source in meters

Eq. (13) includes no correction for multi-path transmission. Free space

radiation is approached by some A.F.M.T.C. sources whose energy is radiated within a very small solid angle, whose antenna is many wavelengths above ground and whose separation distance from the point of squib installation is small enough that the wave front is relatively small. At larger separation distances the wave front is such that large areas are irradiated and significant random reflections may occur. To compensate for this, Eq. (13) must be modified. Previous measurements of field intensities in the various complex areas indicate that allowance for complete field strength reinforcement is more than adequate. The result is an increase in field intensity by four times. As can be seen from Drawing D-94100 (Appendix A) an indicated source may consist of multiple installations and therefore this additional power must also be accounted for. Multiple transmitter installations at A.F.M.T.C. are not phased at radio frequencies and therefore their field strengths do not have to be added vectorially. A correction factor of four applied to Eq. (13) will insure a safe condition and adequate correction for multi-path and multiple installations.

Eq. (13) then becomes

$$P = \frac{ERP}{\pi r^2} \qquad (14)$$

Eq. (14) may now be used in conjunction with Eqs. (6), (7), and (8) to calculate the power absorbed in the "hypothetical" squib.

Power Summation

The power absorbed by the "hypothetical" squib is related to power density and squib effective aperture as follows:

$$W = A_e P_d \tag{15}$$

where

W = Power absorbed in watts

P_d = Power density in watts per square meter

A_e = Effective aperture in square meters

The transition from rhombic to long-wire antenna for a squib with one meter leads occurs at 600 megacycles. Substituting Eq. (7) Eq. (14) into Eq. (15) for all frequencies above 600 mc we have for the power absorbed at each frequency

$$W = \frac{5L_m}{16\pi^2} \left(\frac{ERP \; \lambda_m}{r^2} \right)$$

and for "n" sources

$$W_{t1} = \frac{5L_m}{16\pi^2} \sum^{n} \frac{ERP_n \lambda_n}{r_n^2} \tag{16}$$

For all frequencies between 150 and 600 megacycles substituting Eq. (6) and (14) in Eq. (15) gives

$$W_{t2} = \frac{G}{4\pi^2} \sum^{n} \frac{ERP_n \lambda^2_n}{r_n^2} \tag{17}$$

where G is obtained from Figure 1 on Page 16.

For frequencies 30 to 150 megacycles substituting Eq. (8) and Eq. (14) into Eq. (15) gives

$$W_{t3} = \frac{1.64}{4\pi^2} \sum^{n} \frac{ERP_n \lambda^2{}_n}{r_n{}^2} \qquad (18)$$

Adding Eqs. (16), (17), and (18) gives

Total power absorbed from all radiation sources by an unshielded squib $= W_{t1} + W_{y2} + W_{t3}$ (19)

Total power absorbed from all radiation sources by a shielded squib $= (W_{t1} + W_{t2} + W_{t3})\gamma$ (20)

where

γ = Shielding efficiency

Eq. (19) has been computed and tabulated in Table V for each radiation source irradiating each missile complex, fuel storage area and for two points within the industrial area. The two points chosen within the industrial area are the nearest points to the MOD II and AN/FPS-16 Radars and thus represent the most hazardous condition.

CONCLUSIONS

Individual Radiation Sources

The AN/FPQ-4 (DAMP Ship), AN/FPS-16 and the G. E. Rate and Track radars constitute the greatest hazards individually. This is the result of their large average radiated power and/or the close proximity of these radars to missile complexes or assembly buildings.

The radars located at Patrick Air Force Base and the downrange stations are not hazardous to ordnance items in the Cape Canaveral area.

No hazard exists from HF communications transmitters in the Pads 25A, 25B, 29, 30A and 30B areas, and Missile Assembly Area Hangar Y provided

(1) All squib maximum no-fire D.C. currents are 100 milliamperes or greater.

(2) Squib leads are no longer than seven and one-half feet from squib to either end.

(3) Radiation sources and antennas are limited to those facilities itemized in Tables I and II of Part I of this report.

Personnel handling ordnance items can increase the margin of safety considerably above that provided in this report by observing the following precautions:

(1) Transport ordnance items in metallic containers with cover lids firmly in place.

(2) Keep unshielded leads twisted at all times

(3) Keep ordnance leads as short as possible and shunted with a resistance lower than that of the squib.

(4) Keep ordnance items in metallic shipping containers until ready for installation.

Mobile 30 and 60 watt communication transmitters are not considered hazardous if the following minimum separation distances are maintained:

30 watts	100 feet
60 watts	150 feet

Radiation Sources Collectively

The total absorbed power calculated and tabulated in Table V for each missile complex is based on the following:

(1) All sources are radiating.

(2) Sources with rotatable antennas including duplicate equipment are irradiating the squib with the maximum energy possible including multi-path transmission.

It is very improbable the conditions above would occur simultaneously; however, a squib capable of operating in such an environment without activation will provide the greatest margin of safety.

RECOMMENDATIONS

In those cases where it is impractical to desensitize a squib type with respect to a particular hazardous radiation source or where turning off the radiation source results in an operating problem to the range, it is recommended the use of a portable wire screen baffle, grounded and installed between the ordnance personnel and the radiation source be considered.

As an alternate to a wire screen baffle electromagnetic energy absorbing materials, such as, Emerson and Cuming, Inc. "Eccosorb" types AN and CHW could be used.

Attenuation of about 20 to 30 db can be obtained with either method at frequencies above about 50 megacycles.

In accordance with reference number (8), it is recommended the AFMTC establish the following limitations:

(1) Future electro explosive devices used at AMR have a no-fire current rating no less than one ampere for five minutes for no more than one device per thousand to fire.

(2) Certification be required from the missile contractor that each electro explosive device used on the missile is safe after installation with regard to on-board RF radiation sources, such as telemetry and beacons.

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TABLE I
INVENTORY HIGH FREQUENCY
COMMUNICATIONS TRANSMITTERS

Transmitter Power Output	Transm. Type	Quan. of Transm.	Channels Per Transm.	Total Rad. Sources
250 Watts	30 K4	14	1	14
2.5 KW per CH	96-D	3	3	9
3 KW	231-D	1	1	1
45 KW P.E.P.	Collins S.S.B.	3	1	3
			Sources Total	27

TABLE II
INVENTORY HIGH FREQUENCY
COMMUNICATIONS ANTENNA

Acct. No.	Type	Range	Power Rating	Opt. Freq.	Azimuthal Orientation Degrees
1 & 2	AA Rhombic	4-30 MC	45 KW	12-14 mc	109
3 & 4	D Rhombic	4-30 MC	45 KW	12-14 mc	119 & 127
5 & 6	C Rhombic	4-30 MC	3 KW	12-14 mc	131
7-12	Discone	3-30 MC	3 KW	3-30 mc	Omni-Direct
13	Craig	2-10 MC	250 KW	2-10 MC	Omni-Direct
14	T 2 FD	2-6 MC	3 KW	2-6 MC	Omni-Direct
15	T 2 FD	2-6 MC	3 KW	3-9 MC	Omni-Direct
16	T 2 FD	3-9 MC	3 KW	2-6 MC	Omni-Direct
17	Dipole	3.05 MC	3 KW	3.05 MC	127 & 307

TABLE II
INVENTORY HIGH FREQUENCY
COMMUNICATIONS ANTENNA

Acct. No.	Type	Range	Power Rating	Opt. Freq.	Azimuthal Orientation Degrees
18	Dipole	7.00 MC	3 KW	7.00 MC	127 & 307
19	Dipole	2.00 Mc	3 KW	2.00 MC	127 & 307
20	Longwire	150 feet	1 KW		
21	Longwire	100 feet	1 KW		
22	Interim Whip Center Loaded		250 W	3.3 MC	Omni
23	Interim Whip Center Loaded		250 W	4.5 MC	Omni
24	Interim Whip Center Loaded		250 W	7.35 MC	Omni
25-31	UHF Discone	225-399mc	150 W		Omni
32-43	VHF Unipole	120-150mc	1KW		Omni
44	AS-505 Collins Squirrel Cage		1KW	225-399MC	Omni
45	Log Periodic Collins		22.5 KW	6.5-60 MC	Rotatable Beam.

TABLE III
RADIATION SOURCE CHARACTERISTICS

Radiating System	Average Power output	Antenna Type And Gain	Operation Mode	Fixed Antenna Orientation Degrees	Emission	Wavelength Meters
CAPE CANAVERAL						
Wilcox 96D	2.5 KW	D Rhombic	Fixed	127	.1A1, 6A3	150 to 11.5
Collins 30K4	250 W	Dipole	Fixed	127	.1A1, 6A3	150 to 10
LORAC	0.3 KW	144-Foot Vertical Twr.	Fixed	Omni-directional	.7A2	125
Collins S.S.B.	22 KW	AA Rhombic	Fixed	109	6A3b	100 to 10
ABMA DOVAP	2 KW	0. db	Fixed	Omni-directional	A0	8.13
STL-AGS	**	**	**		**	**
AN/FRW-2	800W	7 db Helix	Track	*NA	300F3	0.74
Collins 240-D	10 KW	8 db Helix	Fixed	Variable settings with limits: elevation 20 to 50 degrees Azimuth 45 to 130 degrees.	300F3	0.75

*NA-Not Applicable.
**This information is classified. It will be furnished to qualified personnel upon request.

TABLE III (Cont'd)
RADIATION SOURCE CHARACTERISTICS

Radiating System	Average Power Output	Antenna Type And Gain	Operation Mode	Fixed Antenna Orientation Degrees	Emission	Wavelength Meters
CAPE CANAVERAL						
AN/FPS-8 Radar	1080W	30.6 db	Rotating	NA	5000P9	0.223
MOD II Radar	500W	37 db	Track	NA	5000P9	0.104
AN/APS-20E Airborne Surveillance	1500W	35 db	Rotating	NA	5000P1	0.104
AZUSA MK I	500W	33 db	Track	NA	A0	0.0592
AZUSA MK II	2000W	35 db	Track	NA	A0	0.0592
AN/FPQ-4 Radar DAMP Ship	2745 W	44.5 db	Track	NA	5000P0	0.0523
AN/FPS-16 Radar	1000 W	44.5 db	Track	NA	5000P9	0.0549

TABLE III (Cont'd)
RADIATION SOURCE CHARACTERISTICS

Radiating System	Average Power Output	Antenna Type And Gain	Operation Mode	Fixed Antenna Orientation Degrees	Emission	Wavelength Meters
CAPE CANAVERAL						
MOD IV Radar	62.5 W	44 db	Track	NA	10000P9	0.0349
BTL Radar	**	**	**	NA	**	**
GE Rate Radar	**	**	**	NA	**	**
PATRICK AIR FORCE BASE						
AN/FPS-20	4.4 KW	35 db	Rotating	NA	1000P0	0.225
AN/FPS-6	3.6 KW	38.7 db	Rotating & Nodding	NA	1000P0	0.108
XN-1/FPS-16	128 W	44.5 db	Track	NA	5000P0	0.0549
AN/CPS-9	230 W	44.5 db	Rotating	NA	10000P0	0.0331
AN/MPN-11C	450 W 45 W	34.6 db 40.0 db	Rotating PAR	NA NA	4000P0 11000P0	0.107 0.033

*NA-Not Applicable
**This information is classified. It will be furnished to qualified personnel upon request.

TABLE IV
INVENTORY OF COMMAND DESTRUCT
TRANSMITTERS - CAPE CANAVERAL

Quantity	Transm. Type	Power Output	Modulation	Location
8	FRW-2	600 W	FM	Bldg. 6-81585
2	240-D (amplifiers)	10 KW	FM	Bldg. 6-81585
2	FRW-2	600 W	FM	Central Control Building

INVENTORY OF COMMAND DESTRUCT
ANTENNAS - CAPE CANAVERAL

Quantity	Transm. Type	Power Gain in DB	Power Rating	Polarization	Location
1	Collins AS-555	8	500 W	Vertical	Bldg. 6-81585
2	Gabriel	6	2 KW	Circular	Bldg. 6-81585
1	High Power Helix	10	10 KW	Circular	Bldg. 6-81585
1	Low Power Helix	8	600 W	Circular	Bldg. 6-81585
1	AMR Steerable Parabolic	24	10 KW	Circular	Bldg. 6-81585
1	Unipole	0.8	10 KW	Vertical	Bldg. 6-81585
1	Gabriel	6	2 KW	Circular	Central Control
1	Collins AS-555	8	500 W	Vertical	" "
1	Low Power Helix	8	600 W	Circular	" "
1	VHF Unipole	3	600 W	Vertical	" "

SIMULTANEOUS CAPABILITIES

Power Output	Quantity	Location
600 W	3 Systems	Bldg. 6-81585
10 KW	1 System	Bldg. 6-81585
600 W	1 System	Central Control Bldg.

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PART I

TABLE V SITE

RADIATION ENVIROMENT

July 1961

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pads 1 & 2
Project: MATADOR

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	6704	.19
MOD II Radar	2.5	4854	.35
AZUSA MK I	1.0	3626	.13
AZUSA MK II	6.32	7867	.19
AN/FPQ-4 Radar on DAMP Ship	77.5	8959	1.60
AN/FPS-16 Radar	28.2	4259	2.71
MOD IV Radar	1.57	3195	.17
BTL Radar GMCF-3	***	3701	.05
GE GMCF Radar:			
Rate	***	4748	.25
Track	***	4748	.15
AN/FRW-2 C/D (C/C)	0.004	4854	negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	6655	1.62
NASA Steerable	0.40	6655	.26
HP Helix	0.10	6655	.06
STL-AGS GE GMCF	***	4748	.06
ABMA DOVAP	0.002	4851	.23
ABMA UDOP	0.002	4851	negligible
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	28200	.12
AN/FPS-6 Radar	26.2	28200	.11
XN-1/FPS-16 Radar	3.62	27100	.01
AN/CPS-9 Radar	6.43	25200	.01
AN/MPN-11C (GCA)	1.3	26250	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pads 3 & 4
Project: Unassigned

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	6997	.18
MOD II Radar	2.5	4860	.35
AZUSA MK I	1.0	3559	.13
AZUSA MK II	6.32	8160	.18
AN/FPQ-4 Radar on DAMP Ship	77.5	9249	1.50
AN/FPS-16 Radar	28.2	4337	2.61
MOD IV Radar	1.57	3399	.15
BTL Radar GMCF-3	***	3747	.05
GE GMCF Radar:			
Rate	***	5011	.22
Track	***	5011	.14
AN/FRW-2 C/D (C/C)	0.004	4860	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	6922	1.49
NASA Steerable	0.40	6922	.24
HP Helix	0.10	6922	.06
STL-AGS GE GMCF	***	5011	.06
ABMA DOVAP	0.002	5124	.21
ABMA UDOP	0.002	5124	Negligible
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	28460	.12
AN/FPS-6 Radar	26.2	28460	.11
XN-1/FPS-16 Radar	3.62	27360	.01
AN/CPS-9 Radar	6.43	25470	.01
AN/MPN-11C (GCA)	1.3	26520	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 5
Project: REDSTONE

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	2283	1.67
MOD II Radar	2.5	5933	.23
AZUSA MK I	1.0	5963	.05
AZUSA MK II	6.32	3447	1.00
AN/FPQ-4 Radar on DAMP Ship	77.5	4445	6.49
AN/FPS-16 Radar	28.2	4688	2.23
MOD IV Radar	1.57	2697	.24
BTL Radar GMCF-3	***	4828	.03
GE GMCF Radar:			
Rate	***	1236	3.69
Track	***	1236	2.22
AN/FRW-2 C/D (C/C)	0.004	5933	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	2483	11.60
NASA Steerable	0.40	2483	1.86
HP Helix	0.10	2483	.46
STL-AGS GE GMCF	***	1236	.96
ABMA DOVAP	0.002	888	6.97
ABMA UDOP	0.002	888	.06
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	24850	.16
AN/FPS-6 Radar	26.2	24850	.15
XN-1/FPS-16 Radar	3.62	23710	.01
AN/CPS-9 Radar	6.43	21740	.01
AN/MPN-11C (GCA)	1.3	22760	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 6
Project: MERCURY REDSTONE

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	2441	1.46
MOD II Radar	2.5	5792	.24
AZUSA MK I	1.0	5808	.05
AZUSA MK II	6.32	3604	.91
AN/FPQ-4 Radar on DAMP Ship	77.5	4594	6.08
AN/FPS-16 Radar	28.2	4550	2.37
MOD IV Radar	1.57	2547	.27
BTL Radar GMCF-3	***	4679	.03
GE GMCF Radar:			
Rate	***	1183	4.03
Track	***	1183	2.43
AN/FRW-2 C/D (C/C)	0.004	5792	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	2557	10.94
NASA Steerable	0.40	2557	1.75
HP Helix	0.10	2557	.44
STL-AGS GE GMCF	***	1183	1.05
ABMA DOVAP	0.002	876	7.15
ABMA UDOP	0.002	876	.06
Communications:			
Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	25000	.16
AN/FPS-6 Radar	26.2	25000	.15
XN-1/FPS-16 Radar	3.62	23860	.01
AN/CPS-9 Radar	6.43	21890	.01
AN/MPN-11C (GCA)	1.3	22910	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 11
Project: ATLAS

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	7435	.16
MOD II Radar	2.5	4026	.51
AZUSA MK I	1.0	2612	.25
AZUSA MK II	6.32	8605	.16
AN/FPQ-4 Radar on DAMP Ship	77.5	9604	1.39
AN/FPS-16 Radar	28.2	3689	3.61
MOD IV Radar	1.57	3247	.16
BTL Radar GMCF-3	***	3028	.07
GE GMCF Radar:			
Rate	***	5137	.21
Track	***	5137	.13
AN/FRW-2 C/D (C/C)	0.004	4026	.01
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	7043	1.44
NASA Steerable	0.40	7043	.23
HP Helix	0.10	7043	.06
STL-AGS GE GMCF	***	5137	.06
ABMA DOVAP	0.002	5327	.19
ABMA UDOP	0.002	5327	Negligible
Communications:			
Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	29280	.12
AN/FPS-6 Radar	26.2	29280	.11
XN-1/FPS-16 Radar	3.62	28170	.01
AN/CPS-9 Radar	6.43	26260	.01
AN/MPN-11C (GCA)	1.3	27310	.01

* Effective Radiated Power: Antenna gain times average radiated power.
** Power absorbed by a hypothetical squib whose leads are 1 meter long.
*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 12
Project: ATLAS

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	7779	.14
MOD II Radar	2.5	3554	.65
AZUSA MK I	1.0	2049	.40
AZUSA MK II	6.32	8946	.15
AN/FPQ-4 Radar on DAMP Ship	77.5	9888	1.31
AN/FPS-16 Radar	28.2	3383	4.29
MOD IV Radar	1.57	3322	.16
BTL Radar GMCF-3	***	2682	.10
GE GMCF Radar:			
Rate	***	5327	.20
Track	***	5327	.12
AN/FRW-2 C/D (C/C)	0.004	3554	.01
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	7205	1.38
NASA Steerable	0.40	7205	.22
HP Helix	0.10	7205	.06
STL-AGS GE GMCF	***	5327	.05
ABMA DOVAP	0.002	5559	.18
ABMA UDOP	0.002	5559	Negligible
Communications:			
Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	29800	.11
AN/FPS-6 Radar	26.2	29800	.10
XN-1/FPS-16 Radar	3.62	28690	.01
AN/CPS-9 Radar	6.43	26770	.01
AN/MPN-11C (GCA)	1.3	27820	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 13
Project: ATLAS

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	8121	.13
MOD II Radar	2.5	3134	.84
AZUSA MK I	1.0	1542	.70
AZUSA MK II	6.32	9281	.14
AN/FPQ-4 Radar on DAMP Ship	77.5	10170	1.24
AN/FPS-16 Radar	28.2	3158	4.92
MOD IV Radar	1.57	3479	.14
BTL Radar GMCF-3	***	2435	.12
GE GMCF Radar:			
Rate	***	5549	.18
Track	***	5549	.11
AN/FRW-2 C/D (C/C)	0.004	3134	.01
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	7385	1.31
NASA Steerable	0.40	7385	.21
HP Helix	0.10	7385	.05
STL-AGS GE GMCF	***	5549	.05
ABMA DOVAP	0.002	5816	.16
ABMA UDOP	0.002	5816	Negligible
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	30300	.11
AN/FPS-6 Radar	26.2	30300	.10
XN-1/FPS-16 Radar	3.62	29190	.01
AN/CPS-9 Radar	6.43	27260	.01
AN/MPN-11C (GCA)	1.3	28300	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 14
Project: ATLAS

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	8565	.12
MOD II Radar	2.5	2807	1.04
AZUSA MK I	1.0	1162	1.26
AZUSA MK II	6.32	9715	.13
AN/FPQ-4 Radar on DAMP Ship	77.5	10550	1.15
AN/FPS-16 Radar	28.2	3088	5.15
MOD IV Radar	1.57	3799	.12
BTL Radar GMCF-3	***	2377	.12
GE GMCF Radar:			
Rate	***	5896	.16
Track	***	5896	.10
AN/FRW-2 C/D (C/C)	0.004	2807	.01
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	7677	1.21
NASA Steerable	0.40	7677	.19
HP Helix	0.10	7677	.05
STL-AGS GE GMCF	***	5896	.04
ABMA DOVAP	0.002	6193	.14
ABMA UDOP	0.002	6193	Negligible
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	30870	.10
AN/FPS-6 Radar	26.2	30870	.10
XN-1/FPS-16 Radar	3.62	29760	.01
AN/CPS-9 Radar	6.43	27820	.01
AN/MPN-11C (GCA)	1.3	28860	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 15
Project: TITAN

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	8997	.11
MOD II Radar	2.5	2585	1.23
AZUSA MK I	1.0	1057	1.52
AZUSA MK II	6.32	10130	.12
AN/FPQ-4 Radar on DAMP Ship	77.5	10910	1.08
AN/FPS-16 Radar	28.2	3122	5.03
MOD IV Radar	1.57	4160	.10
BTL Radar GMCF-3	***	2461	.11
GE GMCF Radar:			
Rate	***	6254	.14
Track	***	6254	.09
AN/FRW-2 C/D (C/C)	0.004	2585	.02
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	7974	1.13
NASA Steerable	0.40	7974	.18
HP Helix	0.10	7974	.05
STL-AGS GE GMCF	***	6254	.04
ABMA DOVAP	0.002	6576	.13
ABMA UDOP	0.002	6576	Negligible
Communications:			
Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	31410	.10
AN/FPS-6 Radar	26.2	31410	.09
XN-1/FPS-16 Radar	3.62	30290	.01
AN/CPS-9 Radar	6.43	28350	.01
AN/MPN-11C (GCA)	1.3	29380	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 16
Project: TITAN

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	9453	.10
MOD II Radar	2.5	2512	1.30
AZUSA MK I	1.0	1303	1.00
AZUSA MK II	6.32	10580	.11
AN/FPQ-4 Radar on DAMP Ship	77.5	11310	1.00
AN/FPS-16 Radar	28.2	3285	4.55
MOD IV Radar	1.57	4583	.08
BTL Radar GMCF-3	***	2699	.09
GE GMCF Radar:			
Rate	***	6657	.13
Track	***	6657	.08
AN/FRW-2 C/D (C/C)	0.004	2512	.02
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	8312	1.04
NASA Steerable	0.40	8312	.17
HP Helix	0.10	8312	.04
STL-AGS GE GMCF	***	6657	.03
ABMA DOVAP	0.002	6998	.11
ABMA UDOP	0.002	6998	Negligible
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	31950	.10
AN/FPS-6 Radar	26.2	31950	.09
XN-1/FPS-16 Radar	3.62	30830	.01
AN/CPS-9 Radar	6.43	28880	.01
AN/MPN-11C (GCA)	1.3	29920	Negligible

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 17A
Project: NASA Projects

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	3447	.73
MOD II Radar	2.5	5175	.31
AZUSA MK I	1.0	4970	.07
AZUSA MK II	6.32	4616	.56
AN/FPQ-4 Radar on DAMP Ship	77.5	5630	4.05
AN/FPS-16 Radar	28.2	3983	3.09
MOD IV Radar	1.57	1881	.49
BTL Radar GMCF-3	***	3976	.04
GE GMCF Radar:			
Rate	***	1641	2.10
Track	***	1641	1.26
AN/FRW-2 C/D (C/C)	0.004	5175	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	3418	6.12
NASA Steerable	0.40	3418	.98
HP Helix	0.10	3418	.24
STL-AGS GE GMCF	***	1641	.54
ABMA DOVAP	0.002	1588	2.18
ABMA UDOP	0.002	1588	.02
Communications:			
Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	25790	.15
AN/FPS-6 Radar	26.2	25790	.14
XN-1/FPS-16 Radar	3.62	24660	.01
AN/CPS-9 Radar	6.43	22700	.01
AN/MPN-11C (GCA)	1.3	23740	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 17B
Project: NASA Projects

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	3282	.81
MOD II Radar	2.5	5310	.29
AZUSA MK I	1.0	5129	.06
AZUSA MK II	6.32	4451	.60
AN/FPQ-4 Radar on DAMP Ship	77.5	5473	4.28
AN/FPS-16 Radar	28.2	4110	2.90
MOD IV Radar	1.57	2013	.43
BTL Radar GMCF-3	***	4120	.04
GE GMCF Radar:			
Rate	***	1584	2.25
Track	***	1584	1.36
AN/FRW-2 C/D (C/C)	0.004	5310	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	3313	6.52
NASA Steerable	0.40	3313	1.04
HP Helix	0.10	3313	.26
STL-AGS GE GMCF	***	1584	.58
ABMA DOVAP	0.002	1491	2.47
ABMA UDOP	0.002	1491	.02
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	25630	.15
AN/FPS-6 Radar	26.2	25630	.14
XN-1/FPS-16 Radar	3.62	24500	.01
AN/CPS-9 Radar	6.43	22540	.01
AN/MPN-11C (GCA)	1.3	23580	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 18A
Project: HETS

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	3916	.57
MOD II Radar	2.5	4861	.35
AZUSA MK I	1.0	4559	.08
AZUSA MK II	6.32	5085	.46
AN/FPQ-4 Radar on DAMP Ship	77.5	6091	3.46
AN/FPS-16 Radar	28.2	3707	3.57
MOD IV Radar	1.57	1617	.66
BTL Radar GMCF-3	***	3633	.05
GE GMCF Radar:			
Rate	***	1933	1.51
Track	***	1933	.91
AN/FRW-2 C/D (C/C)	0.004	4861	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	3788	4.99
NASA Steerable	0.40	3788	.80
HP Helix	0.10	3788	.20
STL-AGS GE GMCF	***	1933	.39
ABMA DOVAP	0.002	1959	1.43
ABMA UDOP	0.002	1959	.01
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	26210	.14
AN/FPS-6 Radar	26.2	26210	.13
XN-1/FPS-16 Radar	3.62	25080	.01
AN/CPS-9 Radar	6.43	23130	.01
AN/MPN-11C (GCA)	1.3	24160	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 18B
Project: Unassigned

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	3791	.61
MOD II Radar	2.5	5046	.32
AZUSA MK I	1.0	4737	.08
AZUSA MK II	6.32	4961	.48
AN/FPQ-4 Radar on DAMP Ship	77.5	5990	3.57
AN/FPS-16 Radar	28.2	3889	3.24
MOD IV Radar	1.57	1795	.54
BTL Radar GMCF-3	***	3818	.05
GE GMCF Radar:			
Rate	***	1948	1.49
Track	***	1948	.90
AN/FRW-2 C/D (C/C)	0.004	5046	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	3767	5.04
NASA Steerable	0.40	3767	.81
HP Helix	0.10	3767	.20
STL-AGS GE GMCF	***	1948	.39
ABMA DOVAP	0.002	1934	1.47
ABMA UDOP	0.002	1934	.01
Communications:			
Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	26030	.15
AN/FPS-6 Radar	26.2	26030	.13
XN-1/FPS-16 Radar	3.62	24910	.01
AN/CPS-9 Radar	6.43	22960	.01
AN/MPN-11C (GCA)	1.3	23990	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 19
Project: TITAN

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	9930	.09
MOD II Radar	2.5	2597	1.22
AZUSA MK I	1.0	1755	.55
AZUSA MK II	6.32	11040	.10
AN/FPQ-4 Radar on DAMP Ship	77.5	11720	.93
AN/FPS-16 Radar	28.2	3556	3.88
MOD IV Radar	1.57	5050	.07
BTL Radar GMCF-3	***	3053	.07
GE GMCF Radar:			
Rate	***	7093	.11
Track	***	7093	.07
AN/FRW-2 C/D (C/C)	0.004	2597	.02
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	8684	.95
NASA Steerable	0.40	8684	.15
HP Helix	0.10	8684	.04
STL-AGS GE GMCF	***	7093	.03
ABMA DOVAP	0.002	7451	.10
ABMA UDOP	0.002	7451	Negligible
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	32500	.09
AN/FPS-6 Radar	26.2	32500	.09
XN-1/FPS-16 Radar	3.62	31380	.01
AN/CPS-9 Radar	6.43	29420	.01
AN/MPN-11C (GCA)	1.3	30450	Negligible

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 20
Project: TITAN

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	10420	.08
MOD II Radar	2.5	2824	1.03
AZUSA MK I	1.0	2293	.32
AZUSA MK II	6.32	11520	.09
AN/FPQ-4 Radar on DAMP Ship	77.5	12150	.87
AN/FPS-16 Radar	28.2	3910	3.21
MOD IV Radar	1.57	5550	.06
BTL Radar GMCF-3	***	3486	.06
GE GMCF Radar:			
Rate	***	7557	.09
Track	***	7557	.06
AN/FRW-2 C/D (C/C)	0.004	2824	.01
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	9084	.87
NASA Steerable	0.40	9084	.14
HP Helix	0.10	9084	.03
STL-AGS GE GMCF	***	7557	.03
ABMA DOVAP	0.002	7927	.09
ABMA UDOP	0.002	7927	Negligible
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	33050	.09
AN/FPS-6 Radar	26.2	33050	.08
XN-1/FPS-16 Radar	3.62	31920	.01
AN/CPS-9 Radar	6.43	29960	.01
AN/MPN-11C (GCA)	1.3	30990	Negligible

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 21
Project: MACE and MATADOR

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	6118	.23
MOD II Radar	2.5	5007	.33
AZUSA MK I	1.0	3933	.11
AZUSA MK II	6.32	7277	.22
AN/FPQ-4 Radar on DAMP Ship	77.5	8388	1.82
AN/FPS-16 Radar	28.2	4272	2.69
MOD IV Radar	1.57	2924	.20
BTL Radar GMCF-3	***	3790	.05
GE GMCF Radar:			
Rate	***	4281	.31
Track	***	4281	.19
AN/FRW-2 C/D (C/C)	0.004	5007	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	6171	1.88
NASA Steerable	0.40	6171	.30
HP Helix	0.10	6171	.08
STL-AGS GE GMCF	***	4281	.08
ABMA DOVAP	0.002	4349	.29
ABMA UDOP	0.002	4349	Negligible
Communications:			
Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	27610	.13
AN/FPS-6 Radar	26.2	27610	.12
XN-1/FPS-16 Radar	3.62	26510	.01
AN/CPS-9 Radar	6.43	24610	.01
AN/MPN-11C (GCA)	1.3	25660	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 22
Project: MACE and MATADOR

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	6223	.23
MOD II Radar	2.5	4970	.33
AZUSA MK I	1.0	3868	.11
AZUSA MK II	6.32	7383	.22
AN/FPQ-4 Radar on DAMP Ship	77.5	8490	1.78
AN/FPS-16 Radar	28.2	4258	2.71
MOD IV Radar	1.57	2961	.20
BTL Radar GMCF-3	***	3762	.05
GE GMCF Radar:			
Rate	***	4360	.30
Track	***	4360	.18
AN/FRW-2 C/D (C/C)	0.004	4970	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	6255	1.83
NASA Steerable	0.40	6255	.29
HP Helix	0.10	6255	.07
STL-AGS GE GMCF	***	4360	.08
ABMA DOVAP	0.002	4436	.28
ABMA UDOP	0.002	4436	Negligible
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	27720	.13
AN/FPS-6 Radar	26.2	27720	.12
XN-1/FPS-16 Radar	3.62	26620	.01
AN/CPS-9 Radar	6.43	24710	.01
AN/MPN-11C (GCA)	1.3	25770	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 25A
Project: POLARIS

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	1486	3.95
MOD II Radar	2.5	6720	.18
AZUSA MK I	1.0	6791	.04
AZUSA MK II	6.32	2656	1.68
AN/FPQ-4 Radar on DAMP Ship	77.5	3741	9.17
AN/FPS-16 Radar	28.2	5469	1.64
MOD IV Radar	1.57	3516	.14
BTL Radar GMCF-3	***	5640	.02
GE GMCF Radar:			
Rate	***	1809	1.72
Track	***	1809	1.04
AN/FRW-2 C/D (C/C)	0.004	6720	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	2363	12.81
NASA Steerable	0.40	2363	2.05
HP Helix	0.10	2363	.51
STL-AGS GE GMCF	***	1809	.45
ABMA DOVAP	0.002	1384	2.87
ABMA UDOP	0.002	1384	.03
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	24030	.17
AN/FPS-6 Radar	26.2	24030	.16
XN-1/FPS-16 Radar	3.62	22900	.01
AN/CPS-9 Radar	6.43	20920	.02
AN/MPN-11C (GCA)	1.3	21940	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 25B
Project: POLARIS

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	1342	4.84
MOD II Radar	2.5	6855	.17
AZUSA MK I	1.0	6936	.04
AZUSA MK II	6.32	2512	1.88
AN/FPQ-4 Radar on DAMP Ship	77.5	3610	9.84
AN/FPS-16 Radar	28.2	5603	1.56
MOD IV Radar	1.57	3659	.13
BTL Radar GMCF-3	***	5780	.02
GE GMCF Radar:			
Rate	***	1919	1.53
Track	***	1919	.92
AN/FRW-2 C/D (C/C)	0.004	6855	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	2352	12.93
NASA Steerable	0.40	2352	2.07
HP Helix	0.10	2352	.52
STL-AGS GE GMCF	***	1919	.40
ABMA DOVAP	0.002	1491	2.47
ABMA UDOP	0.002	1491	.02
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	23900	.17
AN/FPS-6 Radar	26.2	23900	.16
XN-1/FPS-16 Radar	3.62	22760	.01
AN/CPS-9 Radar	6.43	20780	.02
AN/MPN-11C (GCA)	1.3	21800	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 26A
Project: JUPITER

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	2920	1.02
MOD II Radar	2.5	5373	.28
AZUSA MK I	1.0	5338	.06
AZUSA MK II	6.32	4081	.71
AN/FPQ-4 Radar on DAMP Ship	77.5	5047	5.04
AN/FPS-16 Radar	28.2	4141	2.86
MOD IV Radar	1.57	2099	.39
BTL Radar GMCF-3	***	4235	.04
GE GMCF Radar:			
Rate	***	1147	4.29
Track	***	1147	2.58
AN/FRW-2 C/D (C/C)	0.004	5373	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	2821	8.99
NASA Steerable	0.40	2821	1.44
HF Helix	0.10	2821	.36
STL-AGS GE GMCF	***	1147	1.11
ABMA DOVAP	0.002	1005	5.44
ABMA UDOP	0.002	1005	.05
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	25450	.15
AN/FPS-6 Radar	26.2	25450	.14
XN-1/FPS-16 Radar	3.62	24320	.01
AN/CPS-9 Radar	6.43	22350	.01
AN/MPN-11C (GCA)	1.3	23370	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 26B
Project: NASA Projects

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	2762	1.14
MOD II Radar	2.5	5510	.27
AZUSA MK I	1.0	5493	.06
AZUSA MK II	6.32	3924	.77
AN/FPQ-4 Radar on DAMP Ship	77.5	4897	5.35
AN/FPS-16 Radar	28.2	4274	2.69
MOD IV Radar	1.57	2245	.34
BTL Radar GMCF-3	***	4381	.04
GE GMCF Radar:			
Rate	***	1137	4.37
Track	***	1137	2.63
AN/FRW-2 C/D (C/C)	0.004	5510	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	2728	9.62
NASA Steerable	0.40	2728	1.54
HP Helix	0.10	2728	.38
STL-AGS GE GMCF	***	1137	1.13
ABMA DOVAP	0.002	937	6.25
ABMA UDOP	0.002	937	.06
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	25300	.16
AN/FPS-6 Radar	26.2	25300	.14
XN-1/FPS-16 Radar	3.62	24170	.01
AN/CPS-9 Radar	6.43	22200	.01
AN/MPN-11C (GCA)	1.3	23220	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 29
Project: POLARIS

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	1199	6.07
MOD II Radar	2.5	6984	.17
AZUSA MK I	1.0	7078	.03
AZUSA MK II	6.32	2368	2.12
AN/FPQ-4 Radar on DAMP Ship	77.5	3478	10.60
AN/FPS-16 Radar	28.2	5731	1.49
MOD IV Radar	1.57	3797	.12
BTL Radar GMCF-3	***	5916	.02
GE GMCF Radar:			
Rate	***	2026	1.37
Track	***	2026	.83
AN/FRW-2 C/D (C/C)	0.004	6984	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	2340	13.06
NASA Steerable	0.40	2340	2.09
HP Helix	0.10	2340	.52
STL-AGS GE GMCF	***	2026	.36
ABMA DOVAP	0.002	1597	2.15
ABMA UDOP	0.002	1597	.02
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	23760	.18
AN/FPS-6 Radar	26.2	23760	.16
XN-1/FPS-16 Radar	3.62	22630	.01
AN/CPS-9 Radar	6.43	20640	.02
AN/MPN-11C (GCA)	1.3	21670	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 30A
Project: PERSHING

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	2080	2.02
MOD II Radar	2.5	5906	.24
AZUSA MK I	1.0	6104	.05
AZUSA MK II	6.32	3193	1.16
AN/FPQ-4 Radar on DAMP Ship	77.5	4055	7.80
AN/FPS-16 Radar	28.2	4651	2.27
MOD IV Radar	1.57	2803	.22
BTL Radar GMCF-3	***	4880	.03
GE GMCF Radar:			
Rate	***	913	6.77
Track	***	913	4.08
AN/FRW-2 C/D (C/C)	0.004	5906	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	1876	20.34
NASA Steerable	0.40	1876	3.25
HP Helix	0.10	1876	.81
STL-AGS GE GMCF	***	913	1.76
ABMA DOVAP	0.002	484	23.43
ABMA UDOP	0.002	484	.20
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	24830	.16
AN/FPS-6 Radar	26.2	24830	.15
XN-1/FPS-16 Radar	3.62	23690	.01
AN/CPS-9 Radar	6.43	21700	.01
AN/MPN-11C (GCA)	1.3	22720	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 30B
Project: PERSHING

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	1921	2.36
MOD II Radar	2.5	6057	.22
AZUSA MK I	1.0	6264	.04
AZUSA MK II	6.32	3032	1.29
AN/FPQ-4 Radar on DAMP Ship	77.5	3900	8.43
AN/FPS-16 Radar	28.2	4801	2.13
MOD IV Radar	1.57	2964	.20
BTL Radar GMCF-3	***	5037	.03
GE GMCF Radar:			
Rate	***	1044	5.18
Track	***	1044	3.12
AN/FRW-2 C/D (C/C)	0.004	6057	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	1807	21.90
NASA Steerable	0.40	1807	3.50
HP Helix	0.10	1807	.88
STL-AGS GE GMCF	***	1044	1.34
ABMA DOVAP	0.002	617	14.43
ABMA UDOP	0.002	617	.13
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	24680	.16
AN/FPS-6 Radar	26.2	24680	.15
XN-1/FPS-16 Radar	3.62	23540	.01
AN/CPS-9 Radar	6.43	21550	.01
AN/MPN-11C (GCA)	1.3	22570	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are I meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 31
Project: MINUTEMAN

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	4270	.48
MOD II Radar	2.5	5013	.33
AZUSA MK I	1.0	4528	.08
AZUSA MK II	6.32	5439	.40
AN/FPQ-4 Radar on DAMP Ship	77.5	6504	3.03
AN/FPS-16 Radar	28.2	3926	3.18
MOD IV Radar	1.57	1916	.47
BTL Radar GMCF-3	***	3753	.05
GE GMCF Radar:			
Rate	***	2478	.92
Track	***	2478	.55
AN/FRW-2 C/D (C/C)	0.004	5014	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	4315	3.84
NASA Steerable	0.40	4315	.61
HP Helix	0.10	4315	.15
STL-AGS GE GMCF	***	2478	.24
ABMA DOVAP	0.002	2483	.89
ABMA UDOP	0.002	2483	.01
Communications:			
Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	26310	.14
AN/FPS-6 Radar	26.2	26310	.13
XN-1/FPS-16 Radar	3.62	25190	.01
AN/CPS-9 Radar	6.43	23250	.01
AN/MPN-11C (GCA)	1.3	24290	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 32
Project: MINUTEMAN

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	4524	.43
MOD II Radar	2.5	4797	.36
AZUSA MK I	1.0	4266	.09
AZUSA MK II	6.32	5693	.37
AN/FPQ-4 Radar on DAMP Ship	77.5	6740	2.82
AN/FPS-16 Radar	28.2	3738	3.51
MOD IV Radar	1.57	1787	.54
BTL Radar GMCF-3	***	3530	.05
GE GMCF Radar:			
Rate	***	2603	.83
Track	***	2603	.50
AN/FRW-2 C/D (C/C)	0.004	4797	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	4474	3.57
NASA Steerable	0.40	4474	.57
HP Helix	0.10	4474	.14
STL-AGS GE GMCF	***	2603	.22
ABMA DOVAP	0.002	2647	.78
ABMA UDOP	0.002	2647	.01
Communications:			
Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	26590	.14
AN/FPS-6 Radar	26.2	26590	.13
XN-1/FPS-16 Radar	3.62	25470	.01
AN/CPS-9 Radar	6.43	23530	.01
AN/MPN-11C (GCA)	1.3	24570	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 34
Project: SATURN

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	11090	.07
MOD II Radar	2.5	3238	.78
AZUSA MK I	1.0	3116	.17
AZUSA MK II	6.32	12160	.08
AN/FPQ-4 Radar on DAMP Ship	77.5	12720	.79
AN/FPS-16 Radar	28.2	4442	2.49
MOD IV Radar	1.57	6260	.04
BTL Radar GMCF-3	***	4138	.04
GE GMCF Radar:			
Rate	***	8193	.08
Track	***	8193	.05
AN/FRW-2 C/D (C/C)	0.004	3238	.01
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	9610	.77
NASA Steerable	0.40	9610	.12
HP Helix	0.10	9610	.03
STL-AGS GE GMCF	***	8193	.02
ABMA DOVAP	0.002	8581	.07
ABMA UDOP	0.002	8581	Negligible
Communications:			
Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	33800	.09
AN/FPS-6 Radar	26.2	33800	.08
XN-1/FPS-16 Radar	3.62	32670	.01
AN/CPS-9 Radar	6.43	30690	.01
AN/MPN-11C (GCA)	1.3	31720	Negligible

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Pad 36
Project: CENTAUR

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	7178	.17
MOD II Radar	2.5	4291	.45
AZUSA MK I	1.0	2944	.19
AZUSA MK II	6.32	8348	.17
AN/FPQ-4 Radar on DAMP Ship	77.5	9378	1.46
AN/FPS-16 Radar	28.2	3855	3.30
MOD IV Radar	1.57	3186	.17
BTL Radar GMCF-3	***	3227	.07
GE GMCF Radar:			
Rate	***	4982	.23
Track	***	4982	.14
AN/FRW-2 C/D (C/C)	0.004	4291	.01
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	6896	1.50
NASA Steerable	0.40	6896	.24
HP Helix	0.10	6896	.06
STL-AGS GE GMCF	***	4982	.06
ABMA DOVAP	0.002	5145	.21
ABMA UDOP	0.002	5145	Negligible
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	28910	.12
AN/FPS-6 Radar	26.2	28910	.11
XN-1/FPS-16 Radar	3.62	27810	.01
AN/CPS-9 Radar	6.43	25900	.01
AN/MPN-11C (GCA)	1.3	26950	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Hangars E & F
Project: All Projects

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	7012	.18
MOD II Radar	2.5	964	8.85
AZUSA MK I	1.0	2081	.39
AZUSA MK II	6.32	8028	.18
AN/FPQ-4 Radar on DAMP Ship	77.5	8528	1.76
AN/FPS-16 Radar	28.2	382	336.46
MOD IV Radar	1.57	2479	.28
BTL Radar GMCF-3	***	921	.81
GE GMCF Radar:			
Rate	***	4098	.34
Track	***	4098	.20
AN/FRW-2 C/D (C/C)	0.004	964	.12
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	5414	2.44
NASA Steerable	0.40	5414	.39
HP Helix	0.10	5414	.10
STL-AGS GE GMCF	***	4098	.09
ABMA DOVAP	0.002	4510	.27
ABMA UDOP	0.002	4510	Negligible
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	29800	.11
AN/FPS-6 Radar	26.2	29800	.10
XN-1/FPS-16 Radar	3.62	28660	.01
AN/CPS-9 Radar	6.43	26660	.01
AN/MPN-11C (GCA)	1.3	27670	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Hangars N and U
Project: All Projects

Radiation Source Cape Canaveral	ERP* Megawatts	Distance Meters	ASP** Milliwatts
AN/FPS-8 Radar	1.23	8087	.13
MOD II Radar	2.5	620	21.39
AZUSA MK I	1.0	2256	.33
AZUSA MK II	6.32	9071	.14
AN/FPQ-4 Radar on DAMP Ship	77.5	9493	1.42
AN/FPS-16 Radar	28.2	1512	21.45
MOD IV Radar	1.57	3616	.13
BTL Radar GMCF-3	***	1769	.22
GE GMCF Radar:			
Rate	***	5183	.21
Track	***	5183	.13
AN/FRW-2 C/D (C/C)	0.004	620	.30
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	6361	1.77
NASA Steerable	0.40	6361	.28
HP Helix	0.10	6361	.07
STL-AGS GE GMCF	***	5183	.05
ABMA DOVAP	0.002	5603	.17
ABMA UDOP	0.002	5603	Negligible
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		

Patrick AFB			
AN/FPS-20 Radar	13.9	30880	.10
AN/FPS-6 Radar	26.2	30880	.10
XN-1/FPS-16 Radar	3.62	29730	.01
AN/CPS-9 Radar	6.43	27730	.01
AN/MPN-11C (GCA)	1.3	28740	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Hangar Y
Project: POLARIS

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	1343	4.84
MOD II Radar	2.5	6614	.19
AZUSA MK I	1.0	6870	.04
AZUSA MK II	6.32	2423	2.02
AN/FPQ-4 Radar on DAMP Ship	77.5	3292	11.84
AN/FPS-16 Radar	28.2	5360	1.71
MOD IV Radar	1.57	3572	.14
BTL Radar GMCF-3	***	5625	.02
GE GMCF Radar:			
Rate	***	1572	2.28
Track	***	1572	1.38
AN/FRW-2 C/D (C/C)	0.004	6614	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	1607	27.72
NASA Steerable	0.40	1607	4.43
HP Helix	0.10	1607	1.11
STL-AGS GE GMCF	***	1572	.59
ABMA DOVAP	0.002	1174	3.98
ABMA UDOP	0.002	1174	.04
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	24130	.17
AN/FPS-6 Radar	26.2	24130	.16
XN-1/FPS-16 Radar	3.62	22990	.01
AN/CPS-9 Radar	6.43	20990	.02
AN/MPN-11C (GCA)	1.3	22000	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: MINUTEMAN Assembly Buildings
Project: MINUTEMAN

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	5337	.31
MOD II Radar	2.5	2620	1.20
AZUSA MK I	1.0	3130	.17
AZUSA MK II	6.32	6374	.29
AN/FPQ-4 Radar on DAMP Ship	77.5	6951	2.65
AN/FPS-16 Radar	28.2	1365	26.32
MOD IV Radar	1.57	1058	1.55
BTL Radar GMCF-3	***	1737	.23
GE GMCF Radar:			
Rate	***	2422	.96
Track	***	2422	.58
AN/FRW-2 C/D (C/C)	0.004	2620	.02
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	3895	4.71
NASA Steerable	0.40	3895	.75
HP Helix	0.10	3895	.19
STL-AGS GE GMCF	***	2422	.25
ABMA DOVAP	0.002	2829	.69
ABMA UDOP	0.002	2829	.01
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	28120	.13
AN/FPS-6 Radar	26.2	28120	.11
XN-1/FPS-16 Radar	3.62	26980	.01
AN/CPS-9 Radar	6.43	24990	.01
AN/MPN-11C (GCA)	1.3	26000	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Hangar C
Project: All Projects

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	5875	.25
MOD II Radar	2.5	4939	.34
AZUSA MK I	1.0	3938	.11
AZUSA MK II	6.32	7030	.24
AN/FPQ-4 Radar on DAMP Ship	77.5	8139	1.94
AN/FPS-16 Radar	28.2	4152	2.85
MOD IV Radar	1.57	2716	.24
BTL Radar GMCF-3	***	3703	.05
GE GMCF Radar:			
Rate	***	4028	.35
Track	***	4028	.21
AN/FRW-2 C/D (C/C)	0.004	4939	Negligible
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	5916	2.04
NASA Steerable	0.40	5916	.33
HP Helix	0.10	5916	.08
STL-AGS GE GMCF	***	4028	.09
ABMA DOVAP	0.002	4094	.33
ABMA UDOP	0.002	4094	Negligible
Communications: Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	27450	.13
AN/FPS-6 Radar	26.2	27450	.12
XN-1/FPS-16 Radar	3.62	26350	.01
AN/CPS-9 Radar	6.43	24440	.01
AN/MPN-11C (GCA)	1.3	25490	.01

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

TABLE V
SITE RADIATION ENVIRONMENT

Site: Demolition Area
Project: All Projects

Radiation Source	ERP* Megawatts	Distance Meters	ASP** Milliwatts
Cape Canaveral			
AN/FPS-8 Radar	1.23	10980	.07
MOD II Radar	2.5	3036	.89
AZUSA MK I	1.0	3566	.13
AZUSA MK II	6.32	11680	.08
AN/FPQ-4 Radar on DAMP Ship	77.5	12410	.83
AN/FPS-16 Radar	28.2	4250	2.67
MOD IV Radar	1.57	6312	.04
BTL Radar GMCF-3	***	4156	.04
GE GMCF Radar:			
Rate	***	7065	.09
Track	***	8065	.05
AN/FRW-2 C/D (C/C)	0.004	3036	[illegible]
HP C/C Bldg. 6-81585			
AMR Steerable	2.50	9280	.83
NASA Steerable	0.40	9280	.13
HP Helix	0.10	9280	.03
STL-AGS GE GMCF	***	8035	.02
ABMA DOVAP	0.002	8477	.08
ABMA UDOP	0.002	8477	Negligible
Communications:			
Ant. Field	(See written section of report under squib power absorption)		
Airborne Radiation:	AN/APS-20 Radar should not be operated at CCMTA below 5000'		
Patrick AFB			
AN/FPS-20 Radar	13.9	33760	.09
AN/FPS-6 Radar	26.2	33760	.08
XN-1/FPS-16 Radar	3.62	32620	.01
AN/CPS-9 Radar	6.43	30630	.01
AN/MPN-11C (GCA)	1.3	31640	Negligible

* Effective Radiated Power: Antenna gain times average radiated power.

** Power absorbed by a hypothetical squib whose leads are 1 meter long.

*** This information is classified; it will be supplied upon request to qualified agencies.

ANNEX A

PROBABILITY OF ACCIDENTAL IGNITION OF ELECTRIC SQUIBS BY RADIO FREQUENCY ENERGY

by

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Quality Analysis, RCA MTP

July 1961

ABSTRACT

This paper presents a method of determining the factors used to determine the probability that a specified critical power density level in the vicinity of a launch pad may be exceeded by the cumulative effect of various electronic instruments during a four-hour critical period. For the specific pad investigated, the critical level can be exceeded by the concurrent illumination by one dominant radar source and either one of two other radars, but at a probability level of only 10^{-7} or less.

PROBABILITY OF ACCIDENTAL IGNITION OF ELECTRIC SQUIBS BY RADIO FREQUENCY ENERGY

PURPOSE:

This paper attempts to obtain a quantitative estimate of the danger of accidental squib ignition by R.F. energy emanating from electronic instruments; and to develop a method whereby estimates of the probability of accidental ignition can be computed readily for various launching pads.

INTRODUCTION:

During a period of four hours prior to launch, it is necessary to expose electric squibs to electromagnetic radiation from surrounding instruments while each squib is removed from its metal container, hand carried, and finally installed inside a missile. For the sake of simplicity and uniformity, the squib's leads are assumed to form a receiving antenna one meter on a side (1 m facing all directions). The critical power density sufficient to ignite the squib is specified by the manufacturer as 125 milliwatts per square meter. The power density of each radiating instrument, measured in the same units at the target, has been computed. Assuming that these quantities are additive, the problem is to determine the probability that the combined radiations exceed the critical limit.

SCOPE AND LIMITATIONS:

In order to speak of the probability of an occurrence, here the probability of accident, P(A), or the probability of exceeding the critical limit, it is necessary to define the extreme conditions (when accident can and cannot happen), and the assumptions involved. In the latter, the theoretical estimate will tend to favor reducing the chance of "calling a situation safe" when it is unsafe, as compared to the chance of "calling a situation unsafe" when it is safe. Hence, the theoretical estimates tend to be conservative by factors of safety which may reach 100 or possibly higher.

Critical Conditions.

a. If the power density at the target (vicinity of pad) is less than the critical value, the squib is assumed safe, i.e., P(A) = 0.

b. If the power density exceeds the critical value, even for periods as short as a few microseconds, the squib will ignite, i.e., P(A)=1.

Simplifying Assumptions.

a. The critical level is assumed constant and known. Actually, one or more sub-critical transients may be followed by one above the critical level and the squib may not fire (1). The duration of the R. F. energy may be too short to fire, or a portion of the energy is dissipated during a prolonged illumination and the squib fails to fire. There are thus numerous variables which affect ignition, hence the critical level is a fuzzy line rather than a precise mathematical quantity.

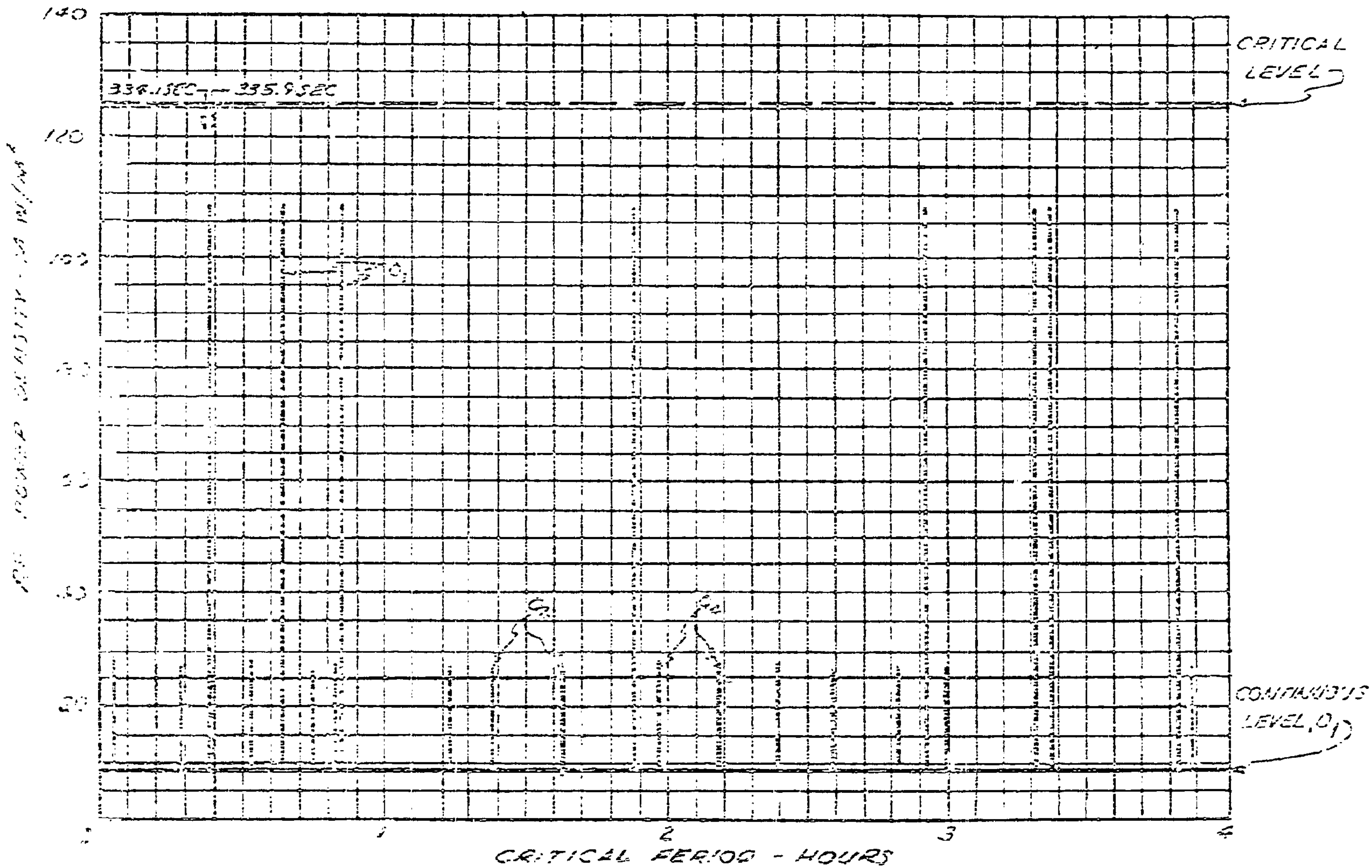
b. It is assumed that conditions which might lead to accidental ignition, e.g. accidental shock, high temperature, static electricity, etc., are not present. Actually, their existence tends to reduce the critical level temporarily and thereby may increase the probability of accidental firing.

c. It is likely that the exposure of squibs is of short duration, a matter of minutes, compared with the assumed critical period of four hours. Hence the joint probability of dangerous illumination and presence of an exposed squib is actually less than if the squib were exposed continuously.

d. The favorable orientation of the "one meter antenna" to two or more instruments at different locations at the same time is convenient for theoretical estimates of exposure time. But the addition of several power densities is not valid, hence the actual probability of the combined power level is considerably less than theoretical.

FIG. 1 RANDOM SWEEPS OF 3 RADAR'S

(N = 8 SWEEPS PER RADAR)



A3

THE PROBABILITY MODEL:

Elemental Quantities.

The radiation of any instrument as seen by the target has two quantities associated with it: a positive magnitude of R.F energy and a time interval during which the target is illuminated. The time interval may be classified as continuous, pulsating, or a spike at a random instant. The first is constant and continuous over the entire critical period. The pulsating type is analogous to the positive half of a square wave with amplitude equal to the power density and time interval equal to one-half the period. The last one's duration is but a fraction of a second.

Elemental Probabilities.

The probability of illumination by any instrument may be taken as the time average or ratio of the total duration of illumination and the total critical period. Thus for the "ith" instrument:

$$P_i(t) = \frac{\sum \Delta t \ \text{(sec)}}{14,400 \ \text{(sec)}} \tag{1}$$

If there are n positive instances of duration Δt:

$$P_i(t) = n\ (\Delta t/1.44)\ 10^{-4} \tag{2}$$

a. For the instrument continuously on target, $P(t) = 1$.

b. For the pulsating instrument, the total duration is half the critical period, hence, $P(t) = 0.5$.

c. For the random sweep by a radar (such as may occur during a random sweep past the target while moving to or from the boresight tower) the probability is governed by the duration of illumination during a sweep and the expected number of sweeps, Equation 2.

Figure 1 illustrates power density versus critical period at a typical launch pad. Q_1 is continuous and constant, Q_2, Q_3 and Q_4 represent three radars each with eight sweeps at random intervals. A pulsating instrument would appear as a square wave with duration equal to half a period.

The most prevalent electronic gear present, radar, is considered to have a definite beam width, a constant rate as it sweeps past the target, and a random instant when it sweeps over the target. The target is represented by one meter width and subtends an angle that is inversely proportional to the distance between instrument and pad. The duration of illumination is: (See Fig. 4)

$$\Delta t = \frac{\theta_b + \theta_s}{\omega} \qquad (3)$$

Where: θ_b denotes beam width of radar, in mils

θ_s = $1/r$ 1000 (mils), and r denotes distance in meters

ω = nominal sweep rate, 5°/sec $\approx$ 100 mils/sec

If the expected number of sweeps during the critical period is n, then:

$$P_i(t) = n_i c_i \; 10^{-4} \qquad (4)$$

Where: $c_i = \Delta t / 1.44$

$1.44 \; 10^4$ denotes the number of seconds in 4-hour critical period

Combinations.

Since the power density level of any instrument is less than the critical level (those exceeding it are silenced), it will take the combined effect of two or more instruments to exceed the critical value. Since the effect of continuous power density is to reduce the tolerance between other instruments and the critical value, (or what amounts to the same thing, it probability is unity) a revised critical value may be used:

$$Q'_{crit} = Q_{crit} - Q_I \qquad (5)$$

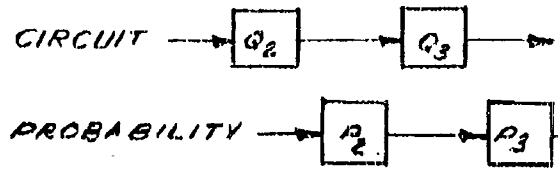
Where: Q_I denotes the sum of instruments with continuous illumination.

Although the power densities of two (or more) instruments are additive, the chance illumination is a product of the two (or more) elemental probabilities:

$$P(2,3) = P_2(t) \cdot P_3(t) \qquad (6)$$

FIG. 8 CIRCUIT ANALOGY

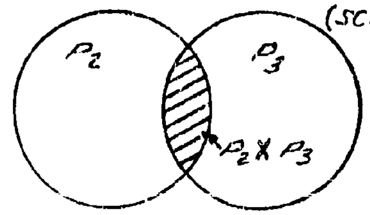
SERIES (CONCURRENT) EVENTS



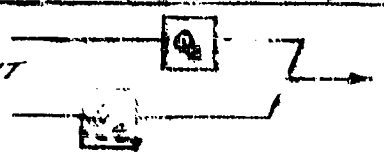
$Q_2 + Q_3 > Q_{CRIT}$ (SUM)

$P_2 \times P_3 = P(A)$ (PRODUCT)

(SCHEMATIC)



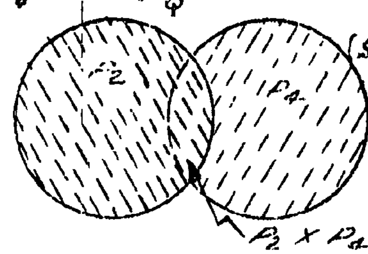
PARALLEL (ALTERNATE) EVENTS



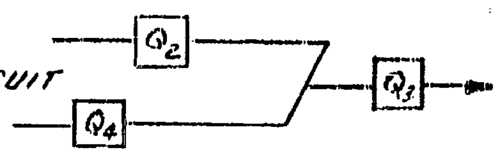
$(Q_2 \text{ OR } Q_4) \geq Q$ (EITHER OR BOTH)

PROBABILITY $P_2 + P_4 - P_2 \times P_4 = P_Q$ (SUM)

(SCHEMATIC)



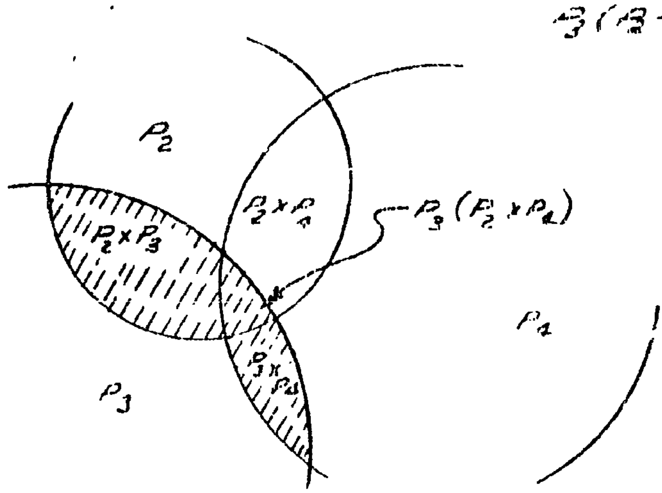
SERIES - PARALLEL (COMBINED) EVENTS



$Q_2 + Q_3 > Q_{CRIT}$ OR $Q_4 + Q_3 > Q_{CRIT}$

$P_3 \times P_Q = P(A)$

$P_3(P_2 + P_4 - P_2 P_4) = P(A)$ (PROB)



(SCHEMATIC)

$P_2 \times P_3 + P_3 \times P_4 - P_2 \times P_3 \times P_4 = P(A)$

$$P(i, j, \ldots k) = P_i(t) \cdot P_j(t) \ldots P_k(t) \qquad (7)$$

This means that the probability of exceeding the critical limit (revised), depends on all possible combinations which can combine to exceed the limit. Thus:

$$P(A) = P(2,3) + P(3,4) + \ldots P(i, j, \ldots k) \qquad (8)$$

In order to simplify the process further, it is convenient to adopt a series and parallel circuit analogy (2): See Figure 2.

Series.

If success depends on concurrent occurrence of two events that are independent of each other, i.e., $Q_2 + Q_3$, with probabilities $P_2(t)$ and $P_3(t)$, respectively:

$$P(a) = P_2(t) \cdot P_3(t) \qquad (9)$$

Parallel.

If success depends on the occurrence of either or both events, Q_2 or Q_4:

$$P(2,4) = 1 - q_2 q_4 \qquad (10)$$

Where: $q_i = 1 - p_i$

But: $q_2 q_4 = (1 - p_2)(1 - p_4) = 1 - p_2 - p_4 + p_2 p_4$

Substituting in Equation 10:

$$P(2,4) = 1 - (1 - p_2 - p_4 + p_2 p_4)$$

Or: $$P(2,4) = P_2 + P_4 - P_2 P_4 \qquad (11)$$

Series-Parallel.

If success depends on an alternative of two occurrences concurrent with a third event, then:

$$P(c) = P_3(P_2 + P_4 - P_2 P_4) \qquad (12)$$

These probabilities are associated with the power densities listed in the table and diagram in Figure 3.

$$P(d) = P_3(P_5 \cdot P_6) \qquad (13)$$

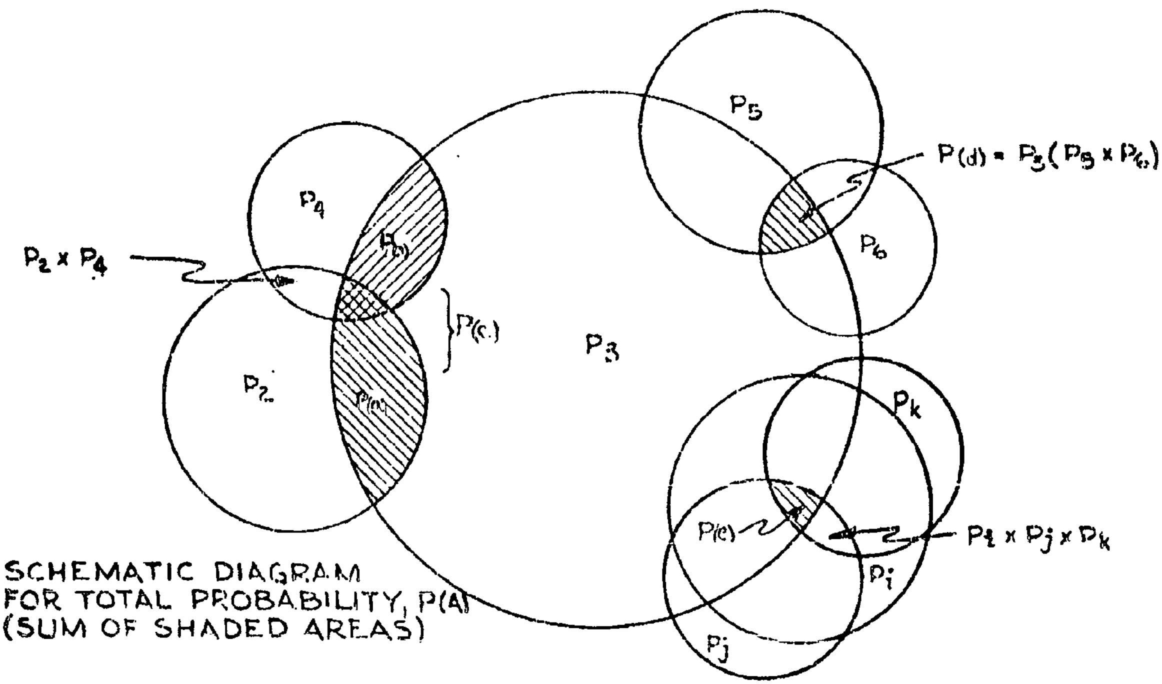
$$P(e) = P_3(P_2 \cdot P_j \ldots P_k) \qquad (14)$$

FIG 3 ARRAY OF COMBINATIONS

P(A)				
P(c)				
P(a)	P(b)		P(d)	P(e)
Q_2				
Q_3	Q_3		Q_3	Q_3
	Q_4			
			Q_5	Q_i
			Q_6	Q_j
				Q_k
SUM $\geq$ Q'CRIT				

ALTERNATE PROB OF P_2 OR P_4

CONCURRENT PROB OF P_i, P_j, P_k W/P_3



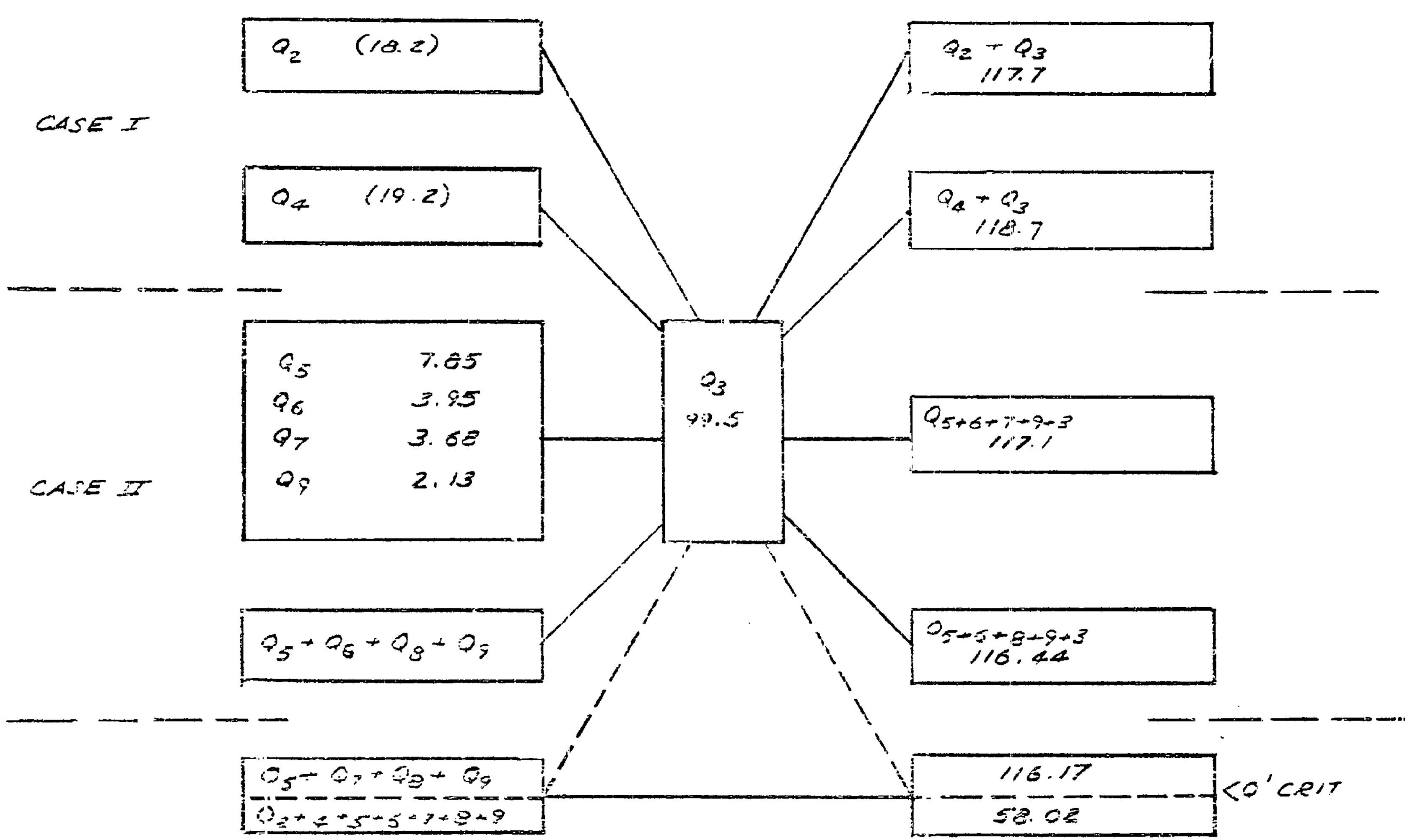
SCHEMATIC DIAGRAM
FOR TOTAL PROBABILITY, P(A)
(SUM OF SHADED AREAS)

$$P(A) = P(c) + P(d) + P(e) \qquad (15$$

TABLE 1. ENERGY SOURCES ILLUMINATING PAD 5

INSTRUMENT	DESIGNATION	POWER DENSITY	NATURE OF INSTR OPERATION	BEAM WIDTH	DURATION OF EXPOSURE	PROBABILITY OF EXPOSURE PER SINGLE SWEEP	RANGE - PAD 5
		MILLIWATT/METER²		MILS	SECONDS (t_i)	10^{-4} (C_i)	METERS
GAT		.59	CONTINUOUS				3,830
C/C		.65	"				2,790
AZUSA		2.21	"				6,000
FRW-2		.01	"				5,940
AFMTC DOVAP		.01	"				4,320
ABMA DOVAP		2.36	"				823
STL AGS		2.73	INTERMITTENT				1,200
	Q_1	9.69	CONTINUOUS			($Q = 1$)	
FPS-4	Q_2	19.2	RADAR	60	0.625	.4340	2,260
CAPE FPS-16	Q_3	99.5	"	21.5	.217	.1507	4,700
MOD II	Q_4	10.2	"	27	.274	.1903	2,630
MOD II	Q_5	7.85	RADAR	45	.450	.3125	5,030
CCA	Q_6	3.95	"	90	.900	.6250	3,810
FPS-16, XN-1	Q_7	3.68	"	21.5	.325	.15625	24,700
FPS-6	Q_8	3.01	"	45	.450	.3125	25,500
BTL	Q_9	2.13	"	45	.450	.3125	4,850
	ΣQ_i	159.2					
CRITICAL LEVEL	Q_c	125.0	REVISED CRIT LEVEL $Q_c' = Q_c - Q_1 = \underline{115.3}$				

TABLE 2 POSSIBLE COMBINATIONS (THAT JUST EXCEED Q'CRIT)



Randon Sweeps of Radars.

For the special condition when the probability of illumination is a joint event of one radar (Q_3), and an alternative (either one or both) illumination by one of two radars (Q_2 or Q_4), the probability is given by Equation 12. Now, if the sweeps continue at random times but their number during a four-hour critical period is taken as a parameter n, then by substituting Equation 4 in Equation 12:

$$P(A) = \left[n_2c_2 + n_4c_4)10^{-4} - (n_2c_2n_4c_4)10^{-8} \right] n_3c_310^{-4} \qquad (16)$$

$P(A) = 0$ when $n_3 = 0$. This means that if radar Q_3 is not present, for the case considered, the chance of exceeding the critical power density and therefore the probability of accident is zero. $P(A) = 1$ when:

$$n_2c_2 = n_3c_3 = n_4c_4 \gtrsim 10^4$$

Sample Results Computed for a Typical Pad.

The array of radiating instruments and their respective power density levels are listed in Table 1. Except for a number of low-power instruments which are treated as continuous and constant, they are radars. The continuous power density level permits several alternative cases which exceed the critical level (Table 2), but only Case 1 need be considered significant. Since Case 1 consists of radars only, P(A) may be related directly to random sweep rate, Equation 16.

Table 3. Probability of 3 radars illuminating target as a function of N.
($N = n_2 = n_3 = n_4$ Random sweeps during 4-hour period)

N	$P(A)\cdot 10^{-8}$
1	0.09 40 81
10	9.40 69 56
100	939.57 54 66

FIG. 4 PROBABILITY AS FUNCTION OF EXPOSURE TIME

DURATION OF SQUIB EXPOSURE DURING ONE SWEEP OF RADAR

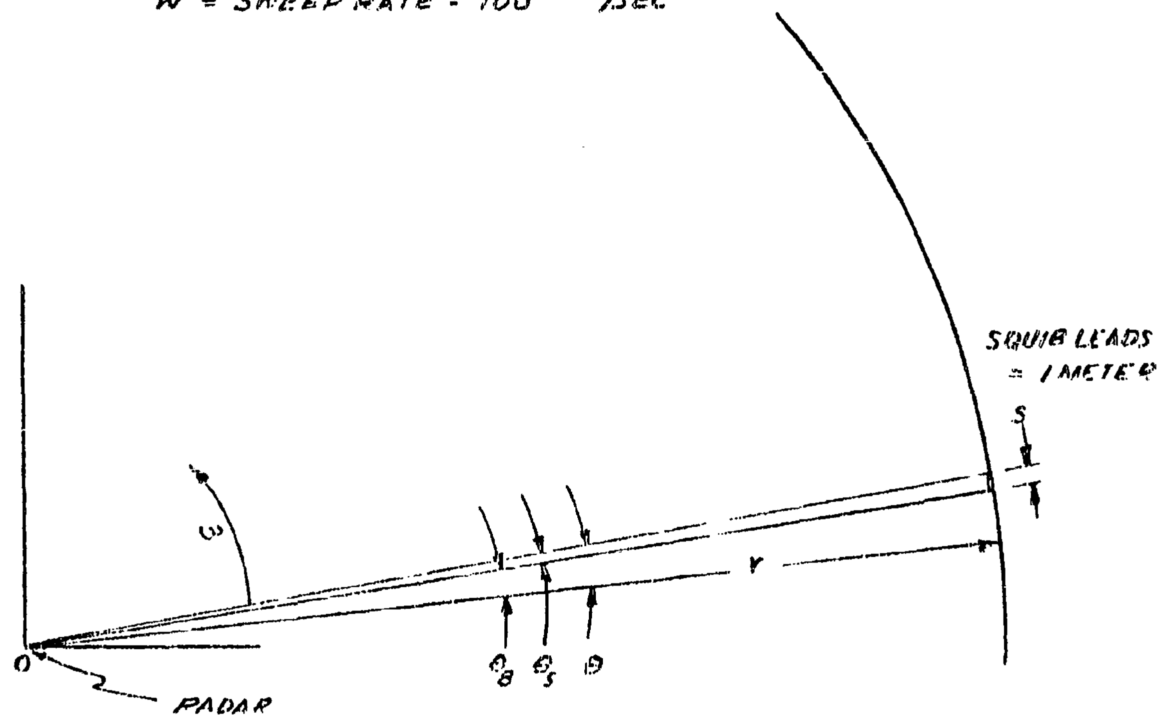
$t = \frac{\theta}{\omega}$ SECONDS

WHERE: $\theta = \theta_B + \theta_S$

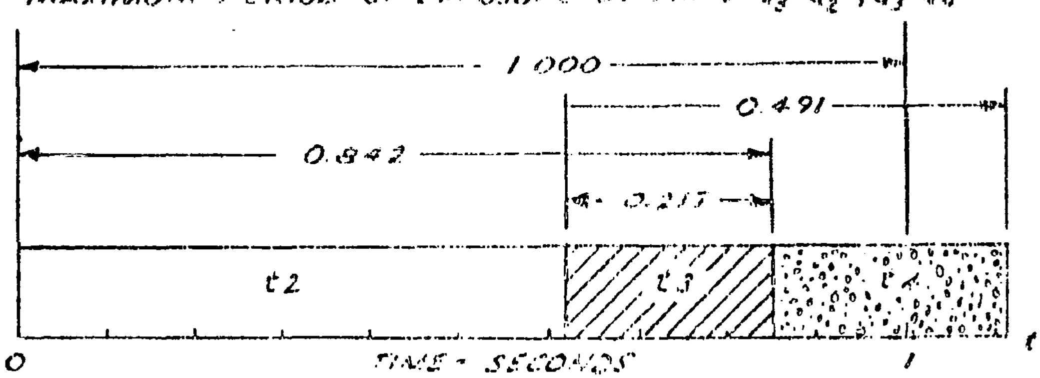
θ_B = BEAM WITH, MILS

$\theta_S = \frac{s}{r} \cdot 1000$, MILS

W = SWEEP RATE = 100 MILS/SEC



MAXIMUM PERIOD OF EXPOSURE BY PAIRS Q_2 Q_2, Q_3 Q_4



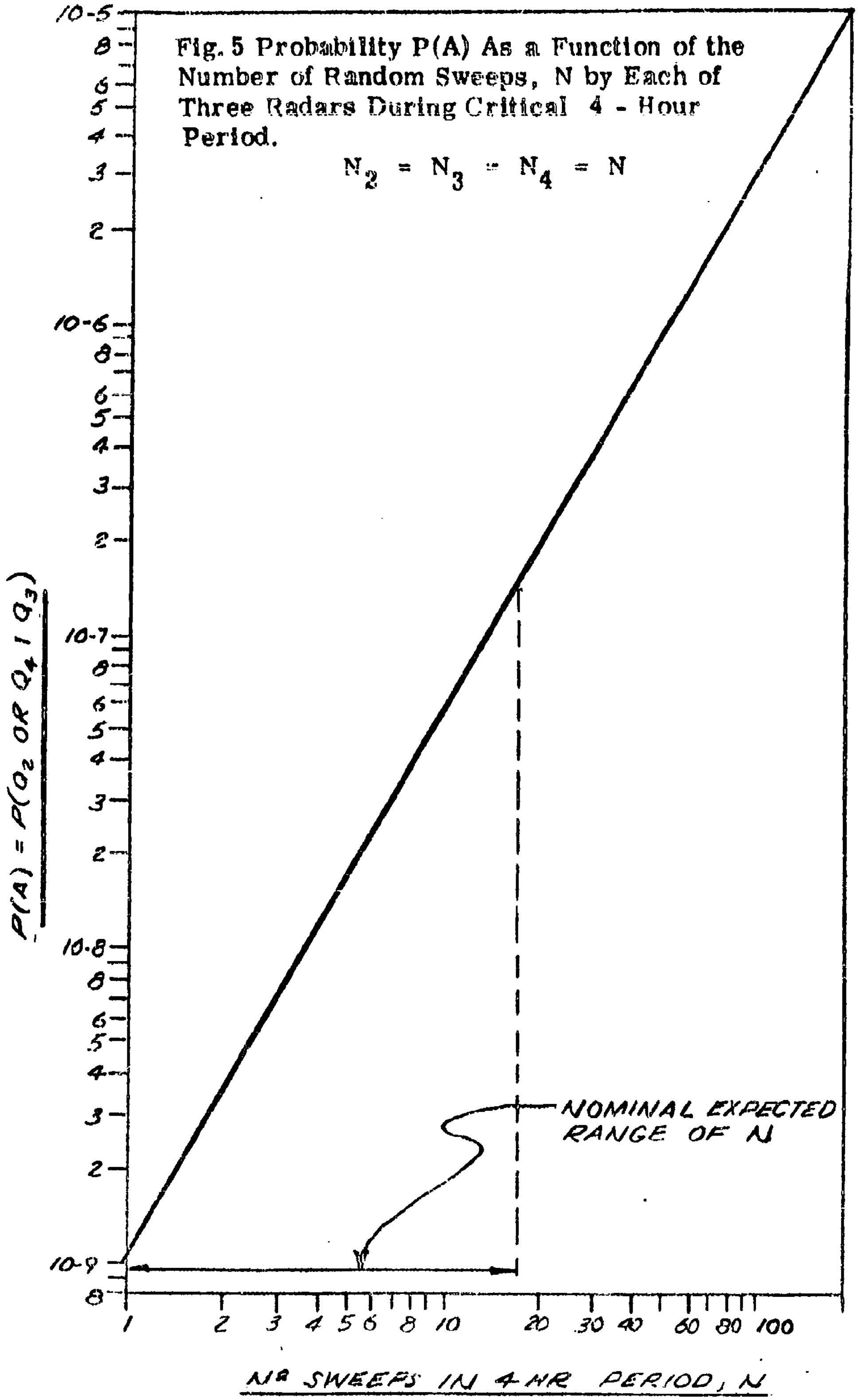


Fig. 5 Probability P(A) As a Function of the Number of Random Sweeps, N by Each of Three Radars During Critical 4 - Hour Period.
$N_2 = N_3 = N_4 = N$
NOMINAL EXPECTED RANGE OF N
$P(A) = P(Q_2 \text{ OR } Q_4 \text{ I } Q_3)$
No SWEEPS IN 4 HR PERIOD, N
10-5
10-6
10-7
10-8
10-9
1
2
3
4
5
6
8
10
20
30
40
60
80
100

Analysis of Results.

Table 3 results are shown in Figure 5. Assuming that the number of random sweeps by each of the three radars involved is in the order of 1 to 12, the probability of exceeding the critical level ranges from 10^{-9} to 10^{-7}. For the case considered, this applies to a continuous power density level of 8.7 milliwatts/square meter. Should this constant level fall below 5.8 mw/m^2, an additional radar would be needed to exceed critical level and consequently the probability would drop by a factor of 10^{-4}.

CONCLUSIONS:

1. For the specific pad conditions, the probability of accidental squib ignition based on the probability of joint illumination of the target by a specific radar and either one of two others is in the order of 10^{-7}. This presupposes a continuous illumination by other instruments amounting to 8.7 milliwatts per square meter. A lower continuous level would require concurrent sweeps by more than two radars, and a resulting drop in probability by 10^{-4}.

2. For any pad, the probability of exceeding a specified safe limit depends on the level of continuously radiating R F sources and the random sweep of a high power density radar beam. If the sum of these two is below the critical level, then the concurrent sweep of two radar beams determines the probability of exceeding the safe limit, and so on for combinations of three, four, or more radars.

3. If there exists an oscillating or pulsating instrument, then the computation of cumulative power densities should be split into two parts, part with constant level and part with oscillating (peak) level, with probability equal to 0.5 in each. Otherwise, the continuous and oscillating quantities may be added to form a new level assumed constant, $P(t) = 1$.

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1. NAVORD Report 4322, "A Discussion of the Mechanism of Initiation of Electrically Fired Explosive Devices by Electro-Mechanically Propagated Energy", 28 June 1956, by J. S. Ayres.

2. NAVORD Report 4135, "Relative Accident Probability Analysis", 1 November 1955, by D. E. Allmand, J.H. Armstrong & others, (Conf.)

3. W. B. Davenport, Jr., and W. L. Root, "An Introduction to the Theory of Random Signals and Noise", N.Y., McGraw-Hill Book Company, Inc., 1958.

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PART II

BIO - EFFECTS

RF RADIATION HAZARDS
July 1961

INTRODUCTION

The development and use of high power radar and communications equipment stimulated a great deal of interest in research in the area of possible biological effects which may result from exposure to RF and X-Radiation.

Of these two types of radiation, micro-wave radiation presents the greater hazard to operating and maintenance personnel. It is evident that many devices now in use at instrumentation sites on the Atlantic Missile Range can produce X-Radiation. It should be noted, however, that shielding to provide adequate personnel protection has been made an integral part of all high power tubes employed in such devices. Maintenance personnel who could be subjected to X-Radiation during maintenance and repair of these devices are provided with suitable safety instructions in the maintenance and instruction manuals for the respective equipment. Adherence to these safety and maintenance instructions will provide adequate protection from X-Radiation.

Microwave radiation injury has been demonstrated in animals, but has not been observed clinically in electronics personnel. Animal eyes were found to be vulnerable to the shorter wavelengths. The injury resulting from microwave radiation appeared to be thermal in nature.

Based on evidence that injury had been caused to animals, and could possibly be caused to personnel, all available information was researched

in an effort to establish a safe exposure level to this form of possible injury. Sufficient factual data is not available to determine the safe exposure level for each frequency; therefore, it was decided to select one level satisfactory for all frequencies.

Past research indicated that a power density of 0.2 watts/cm^2 was required to produce damage. The accuracy of the methods and instrumentation used was somewhat questionable, and possibly some cases of reported damage might have been caused by power densities of approximately 0.1 watts/cm^2. The expanded use of electronics has also resulted in adding minute amounts of RF energy from incidental sources at many frequencies. Since it is impractical to measure the power density at each of these frequencies, a safety factor of 10 was selected and the present level of .01 watts/cm^2 was established. This level is the maximum for either continuous or intermittent exposure.

DISCUSSION

With the growing interest in the biological effects of microwave radiation, many rumors have circulated concerning the possible effects to electronics personnel subject to radiation for microwave generating devices. As is generally the case with such rumors, the effects of radiation on personnel have become exaggerated and distorted. Hazards to personnel do exist and should not be discredited; however, recent experiments with laboratory animals have disclosed that the present level 0.01 watts/cm^2 power density as a maximum safe level is a valid and safe figure, and has an additional safety factor of 10 built in.

The distance from each instrumentation site at Cape Canaveral and Patrick Air Force Base where the power density will equal or exceed the level of 0.01 watts/cm^2 has been calculated and is listed in Table I. It should be noted that these distances are calculated for the level present in the main beam of the antenna. Many locations much closer to the radiating source will not be subject to this power level due to the fact that the antenna in many cases cannot illuminate the area in question.

The following method is used at AFMTC to determine safe distances. It takes into account reduced gain in the Fresnel Zone and includes adequate safety factor.

Round Apertures

Step 1 Determine whether or not a hazard exists anywhere in the field by substituting in the following formula:

$$Pd\ max = 4\frac{W}{A}$$

where Pd max = maximum possible power density in watts/sq CM

W = maximum power input into the antenna (average power) in watts

A = area of the antenna aperture in sq. CM

If Pd max equals or exceeds .01 watts per square CM, a hazard exists somewhere in the field.

Step 2 Calculate the minimum safe distance from the following formula:

$$D = \sqrt{\frac{GW}{400\pi}}$$

Where D = minimum safe distance in meters

G = gain of the antenna

W = maximum power input into the antenna (average) in watts

For any other antenna shape, the same method will apply with the following exception.

In Step 1 - A will be calculated as though the antenna had a round aperture circumscribed about the actual antenna aperture. That is,

$$A = \frac{\pi D^2}{4}$$

Where D = the longest distance across the antenna aperture.

Radiation hazard measurements have been performed on the sites marked with an asterisk in the Table I. In each case the measurements performed indicate that the actual measured power density at the distance indicated in the table is somewhat less than the maximum safe figure of .01 watt/cm^2

The exact distance where the power density becomes 0.01 watt/cm^2 has not yet been determined, but all measurements made to date indicate that the distance will be something less than that listed in Table I.

Measurements performed and tabulated on MOD-II Radars indicates that no hazard exists at any distance from the antenna. The theoretical distance from the MOD II Radar where the maximum exposure level of 10 mw/cm^2 would exist in 146 feet. This is obtained by computation using the far field formula $d=\sqrt{\frac{ERP}{4\pi pd}}$. This distance is within the "near field" of the antenna defined as $\left(\frac{L_t^2}{\lambda}\right)$ where L_t = largest linear dimension of the antenna. The "far field" formula becomes incorrect at this distance, and a correction factor must be applied. This correction factor is dependent on the size and type of antenna in use. At some point within the "near field" the power density will be at a maximum, and the distance at which this maximum occurs is dependent on the antenna dimensions.

While no hazard exists from the MOD-II Radar, it serves as a good example of the power density distribution within the "near field". Measurements at 15 feet from the antenna indicate a power density of about 1 mw/cm^2, while measurements at 35 feet indicate a power density of 3 mw/cm^2. At a distance of 109 feet the power density is 6 mw/cm^2. At any distance greater than 109 feet the power density decreases by the inverse distance square law.

This serves to point out an important point when measuring power densities in questionable areas. A measurement may indicate no hazard when taken in close to the antenna, while a hazard may exist at some greater distance.

Measurements performed in a questionable area should be done with caution, and they should include careful consideration of the "near field" power distribution.

Measurements were performed at the FPS-16 radar site at Cape Canaveral on 5 June 1959. The results of this survey are as follows:

1. No measureable radiation was observed on the antenna pedestal or service platform to the side and rear of the dish.

2. The entire roof of the building should be considered a hazardous area with the exception of the service platform and antenna pedestal to the side and rear of the dish. Due to maximum

depression angle of the antenna, the measurements on the roof of the building were not in the main beam, and do not reflect the maximum power density that could be encountered at heights above 6 ft from the roof. The measured power density at a point near the edge of the roof and at a height of approximately 6 ft was above the maximum exposure level of .01 watts/cm^2.

3. The power density measured at a point near the intersection of the FPS-16 access road and Skid Strip Road was .0092 watts/cm^2. This is near the maximum exposure level, and if the power were raised slightly, this position would become hazardous when illuminated with the main beam of the antenna.

4. Points close in to the FPS-16 building including the parking areas to the font and side of the building are not subject to illumination by the antenna and no hazardous levels exist in these areas.

Conclusions

To avoid unnecessary hazards, the following precautions should be observed:

1. All areas in which RF power densities of 0.01 watts/cm^2 are suspected or detected should be considered hazardous areas.

2. All such areas subject to ingress by personnel should be appropriately posted with warning signs. Personnel should not be permitted in such areas except under emergency conditions, and periods of exposure in these areas should be kept to an absolute minimum.

3. Where test procedures require free space radiation, the radiating device should be oriented in such a manner as to avoid directing the beam toward inhabited areas or other personnel groupings. Care should be taken to avoid directing either the primary beam or accessory lobes in such a manner as to expose personnel in adjacent areas.

TABLE I

MAXIMUM OUTWARD RADIAL DISTANCE FROM RADIATING ANTENNA AT WHICH THE POWER DENSITY WILL EQUAL OR EXCEED 0.01 WATTS/CM^2

Instrumentation AMR	Effective Radiated Power	Distance (feet)
MOD II Radar *	2.5 Megawatts	No hazard**
MOD IV Radar *	1.57 Megawatts	No hazard
FPS-8 Radar *	1.23 Megawatts	No hazard
BTL	***	No hazard
G. E. (Rate)*	***	218.0
G. E. (Track)*	***	No hazard
FPS-16*	28.2 Megawatts	492.0
FPQ-4*	77.5 Megawatts	610.0
AZUSA MK I*	1.0 Megawatts	92.5
FRW-2 C/C	2.0 Kilowatts	5.8
AZUSA MK II	6.3 Megawatts	230.0
10 KW C/C AMR Steerable Antenna	2.5 Megawatts	146
10 KW C/C Helix (NASA)	692.0 Kilowatts	77
10 KW C/C Sterling Antenna	270.0 Kilowatts	48
10 KW C/C any Antenna		10
FPQ-6	630 Megawatts	2300
FPS-6 Radar*	26.6 Megawatts	No hazard
FPS-20A Radar *	13.9 Megawatts	No hazard
CPS-9	6.43 Megawatts	No hazard

* Sites at which radiation measurements have been made. See Bibliography - Bio-Effects

** Determined not to be a hazard by Field Measurements.

*** Classified Information.

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PART III

FUEL

RF RADIATION HAZARDS
July 1961

INTRODUCTION

Of the three general areas of RF radiation hazard on the Atlantic Missile Range, that of combustible liquids has undoubtedly received the least attention. Although power densities of much greater magnitudes are required to create fuel hazards than in the bio and ordnance field, once such a critical density has been reached, the potential hazard may be even greater. An Air Force standard of 5 watts/cm^2 peak has been established by the Rome Air Development Center as the critical power density which must not be exceeded in locations where fueling operations are in progress. The RF radiating systems at AMR are shown in Appendix I. Table I, on Pages 4 and 5 indicates areas around these systems that are considered hazardous to fueling operations.

DISCUSSION

The peak power density of 5 watts/cm^2 was established using a synthetic, highly volatile fuel made of methane. Since the volatility of this fuel is greater than that of high test aviation gas, automobile gasoline, diesel fuel or kerosene, contours established using 5 watts/cm^2 will allow more than ample safety factor for these commonly used petroleum derivative fuels. This critical power density is relatively high, therefore, it will be found at relatively short distances from the radiating system and then only while the area of concern is being illuminated.

Further safety factor is injected when it is realized that ignition of petroleum fuel cannot be caused by RF irradiation alone. There are two conditions that must be met in order to cause ignition:

1. The liquid fuel must be vaporized such that a combustible ratio exists.

2. The electromagnetic field must create a potential difference sufficient to cause an electric discharge through the vapor.

The presently used critical level was established using an ideal combustion ratio for the methane fuel and the RF induced electric discharge was obtained only by placing metal chips in the vapor.

With the above facts in mind, ordinary static charges sometimes built up on moving, insulated vehicles are to be considered more dangerous than RF irradiation. Normal operating techniques which require grounding vehicles and fuel delivery apparatus greatly reduce these hazards and even further reduce RF hazards.

Although fueling operations might occur within the critical contour for some of the devices listed in Table I, they have been noted as No Hazard because of the beam configuration, shielding effect of nearby objects and/or elevation of the radiating system above the area of concern.

Because of the large built-in safety factor inherent in these considerations additional margin for multipath addition of RF energy has not been incorporated.

In the "fresnel"region of an antenna the power density curve no longer follows the far field $\frac{1}{D^2}$ distribution. Therefore a determination must be made as to whether the 5 watts per square CM level is possible with the particular source under consideration. The absolute maximum power density is equal to 4 times the peak power distribution across the aperture. The procedure for determining fuel hazards is the same as that described in Part II page 3 for Biological Hazard determination with the exceptions that peak power is used for the calculations and the limit is 5 watts peak/sq. CM rather than .01 watts average/sq. CM.

TABLE I
MAXIMUM OUTWARD RADIAL DISTANCE FROM RADIATING ANTENNA AT WHICH FUEL HAZARD WOULD EXIST

Instrumentation	Peak Power Watts	Antenna Gain	Distance Feet
MOD II Radar	400,000	5010	185
MOD IV Radar	250,000	25,100	327
FPS-8 Radar	1,000,000	1140	140
10KW Command/Destruct	20,000	6.3	**
BTL Radar	****	****	327
G. E. Rate Radar	****	****	**
G. E. Track Radar	****	****	164
FPS-16 Radar	1,000,000	28,200	695
FPQ-4 Radar	3,050,000	28,200	1210
Azusa Mark I	1000	1990	**
FRW-2 Command/Destruct	1600	5	**
STL "AGS" Transmitter	****	****	**
ABMA DOVAP	4000	1	**
GAT Command	10,000	1216	**
FPQ-6 Radar	3,000,000	126000	2500
FPS-6 Radar	3,500,000	7400	404*
FPS-20A	3,000,000	3160	404*
CPS-9	250,000	28,000	344***

* These radars have been checked by RCA FCA and RADC personnel. No hazard was found to exist to fuel at the Phillips 66 service station located at the South Boundary of PAFB, nor to traffic on highway A1A adjacent to these radars. Reports are available on these investigations. See Bibliography - Fuel.

** Fuel should not be handled within 10 feet of any radiating antenna.

*** No radiation hazard to fuel exists from this radar at elevation angles of 0 or greater. Caution should be exercised during fueling operations in the ramp area to the South and Southwest of Hangar 800 when the radar is operated at depression angles below 0 degrees.

**** Classified information.

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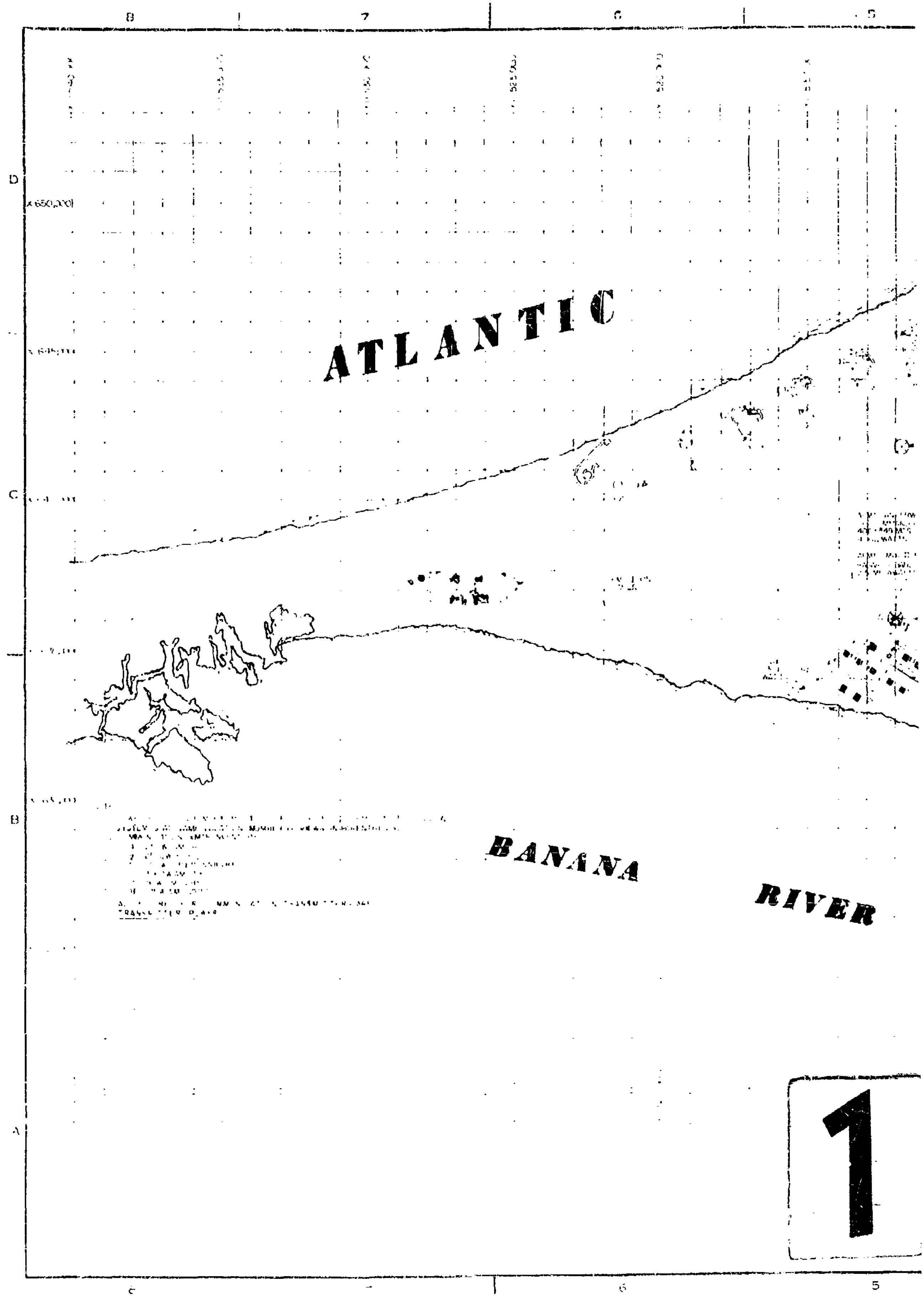
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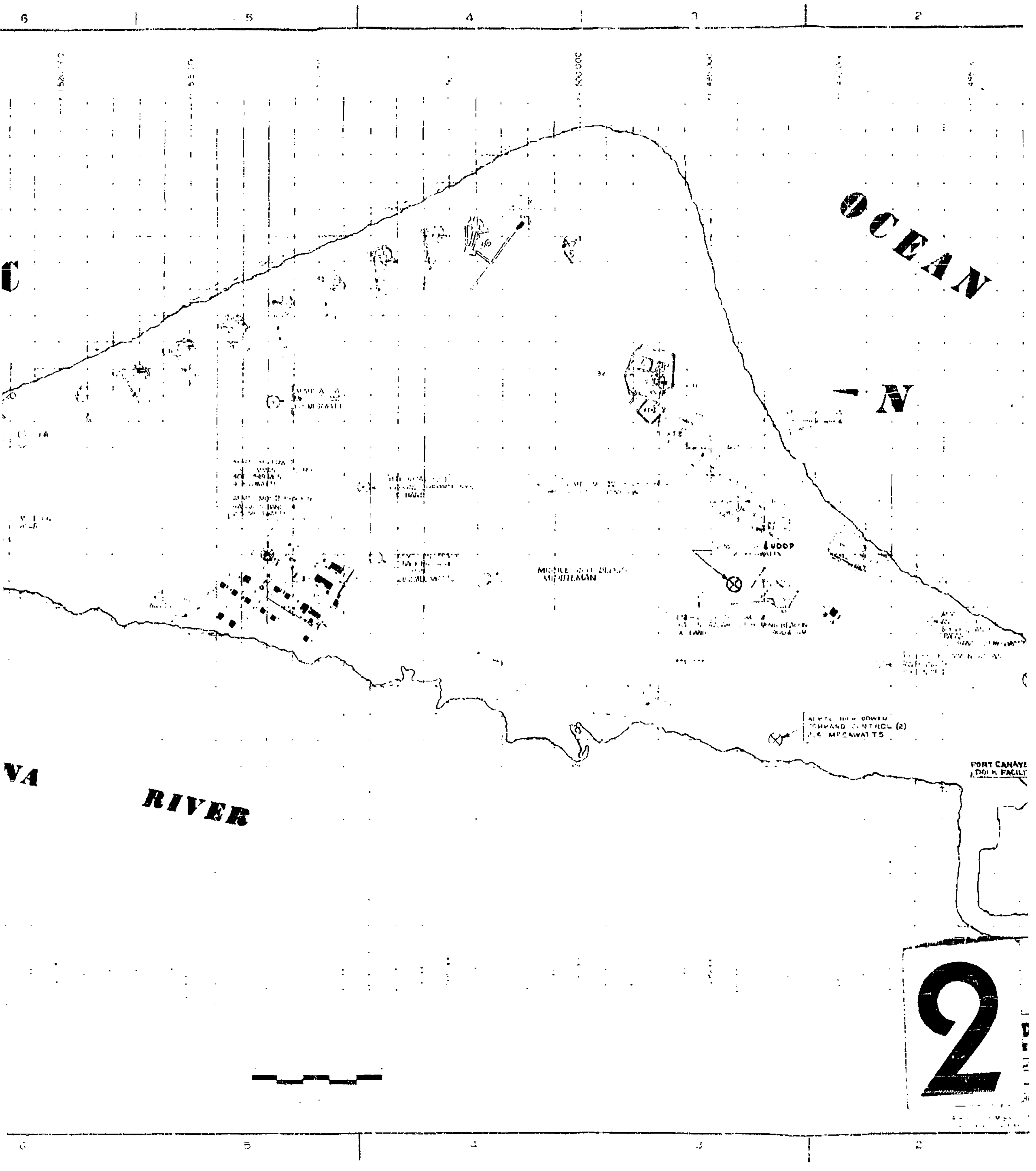

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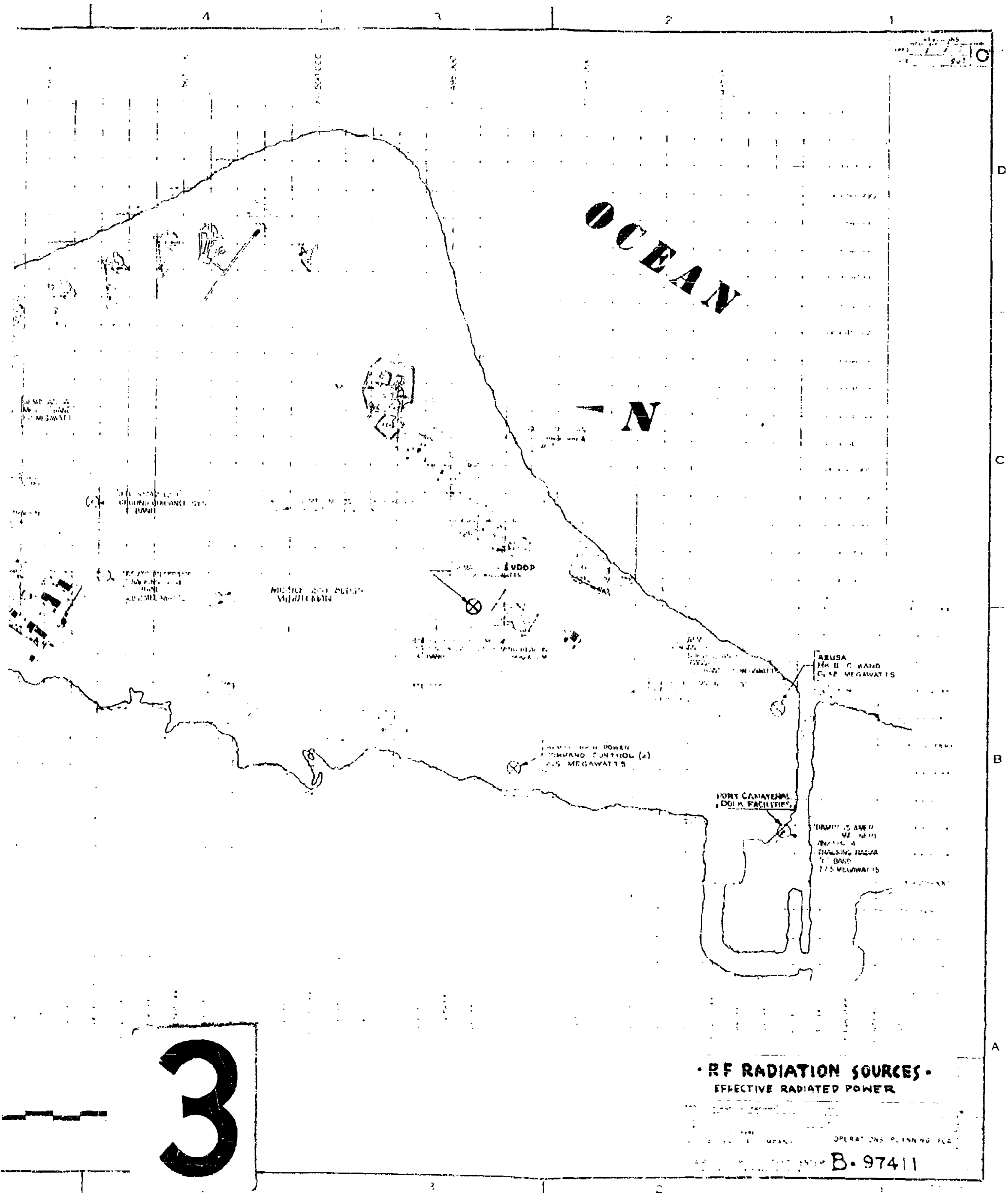
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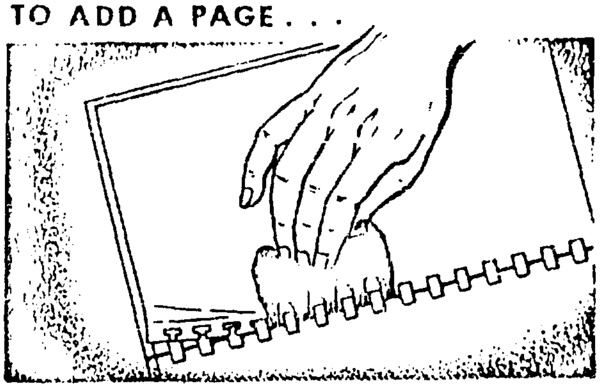

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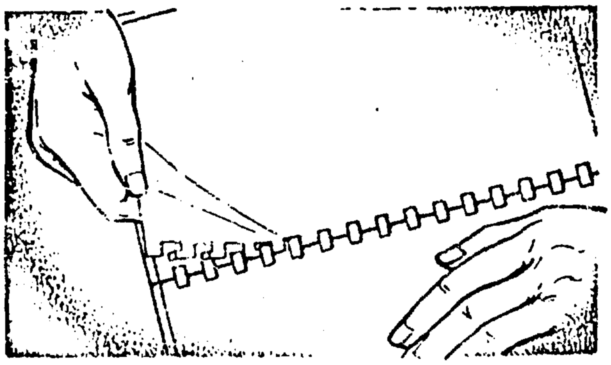

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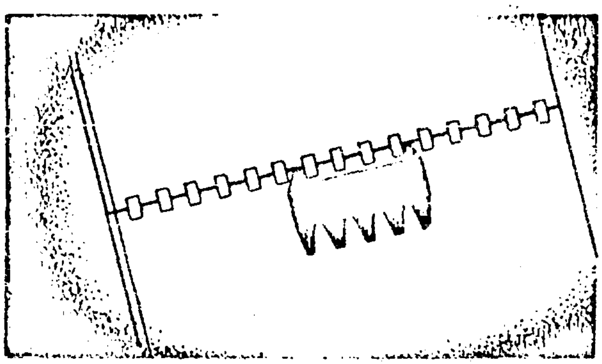

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